A Comparative Study on the Treatment of Eutrophic Water by Aeration and Algae Fish

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Abstract: With the introduction of relevant national policies, large numbers of environmental projects were carried out for remediation and quality improved, but in the main indicators of long-term quality control and operational cost are still a big issue. In this study, the effects of water quality control by aeration and algae-eating fish species, *Mugil cephalus* and *Salmoniformes*, were applied to the test in a landscape pond. The results showed that both ways had similar effect on the pollutants, CODCR, total nitrogen and total phosphorus decreased by about 56%, 59% and 35% respectively, and the water transparency also improved significantly. However, before the application of ecological management in real project, detail environmental conditions and pollution load analysis should be carried out for ensuring safety and efficiency.

1. Introduction
Recent years, improvement of water environment quality is urgent which the number of black smelly water was increasing. The comprehensive remediation of domestic lakes was mainly based on engineering measures such as interception of pollutants, water diversion, aeration, and sediment dredging [1], but the long-term maintenance after treatment was usually not concerned. Based on the concept of ecosystem restoration, water ecological treatment measures are adopted to transform the damaged water body, reduce black odor and bloom, and establishes self-cleaning natural water body. Classical biological manipulators abroad advocated use the fish-eating fish to control planktonic fish, so as to expand the zooplankton population that can contain algae [2]. However, due to the large variety of algae, aquatic animals with narrow dietary and environmental adaptability are difficult to solve the algae problems, so it is necessary to find non-classical but more effective biological control pathways. Algae-eating fish is one of the more implementable studies[3]. Domestic researches on algae-eating fish mainly focused on large lakes, such as silver carp and bighead carp, which were not suitable for small water bodies because of their large size. However, small water bodies have great impact on people's daily life, so putting appropriate algae-eating fish species into small water bodies can greatly improve the improvement effect of environmental remediation[4]. This study provides a basis for the systematic treatment of eutrophic water with high efficiency and low energy consumption by comparing the pollution control effect of aeration flow measures and algae-eating fish [5].
2. Test materials and methods

2.1. Test location
The test site was selected as a landscape lake in a residential district in Jiaodong, Shandong Province. The lake surface area is about 100,000 m², and the average water depth is 1 m. There is no external water source on the daily basis, it is supplemented by rainwater. The lake is long-term black and odorous, the harmful algal blooms occurred frequently which have given damage to the surrounding landscape, seriously affect the lives of nearby residents. Set up two test area with about 4000 m² each, it is isolated from the north side of the landscape by constructing earth dams for algae-eating fish test and aeration flow test, and the water area outside the dam was used as a control test water body.

2.2. Test material equipment

2.2.1. Algae-eating fish. The fish used in this experiment mainly consisted of algae-eating fish species of Mugil cephalus and Salmoniformes. Considering the feeding habits of these two fishes, it is more suitable to control the filamentous algae and cyanobacteria common in landscape waters, and the size of the fish body is suitable for the landscape water and has certain ornamental qualities. The algae-eating fish is cultivated by the breeding base of Guangzhou Water Principle Environmental Remediation LTD. We choose the half-age fish with strong body and no injury, and the average length is about 5cm. Use the lake water for half a day before putting the algae-eating fish into the lake. After the fish adapt to the environment, placed in the lake.

2.2.2. Aeration flow equipment. Selecting the solar aeration equipment produced by Guangzhou NewEarth Environmental Protection Industry Co., Ltd., without additional power supply, using the lifting push flow to break the water layer stratification and aeration and oxygenation, each regenerative oxygen can reach 38g/m² per day. The service water area can reach 6660m².

2.2.3. Testing equipment. The equipment used in this test mainly includes: pH meter, METTLER SG2-FK; dissolved oxygen meter, METTLER SG9-FK2; UV-visible spectrophotometer, THERMO GENESYS 10S UV; COD digestion tester, MERCK single-parameter COD tester and Digestion furnace; steam sterilizer, Shanghai Boxun YXQ-LS-100A; transparency detector, black and white Seychelles disk.

2.3. Test methods

2.3.1. Algae control algae test. The algae-eating fish were released into the test pool, and regularly monitored the changes in water quality indicators (transparency, CODCr, total nitrogen, total phosphorus) before and after, to evaluate the effect of algae-eating fish release treatment on water quality. About 4,000 algae-eating fish were placed, to observe the changes of water quality sampling inspection.

2.3.2. Aeration flow test. Place a solar aeration device in the center of the test cell, set the automatic start-up time from 8:00 to 17:00 every day, observe the sample of water quality and periodically, compare the results of water quality changes (transparency, CODCr, total nitrogen, total phosphorus) before and after placement, To evaluate the effect of aquaculture treatment on water treatment.

2.4. Test time
This pilot project will start from March 2016 to June and will be divided into 2 phases:

The first stage: from March to May, mainly based on site exploration, isolation engineering construction, water quality monitoring, and preparation for follow-up tests;

The second stage: In June, algae-eating fish and aeration flow equipment were placed in the test area,
and the water quality changes were monitored.

2.5. Water quality testing and data processing

Three sampling points are set in each of the two test areas, and three sampling points are determined outside the test area.

The water transparency and sensory status (odor, water color, turbidity, etc.) are monitored every day from 8 to 9 am, and all points are sampled every Monday. Detection immediately after each water sample is taken, the test includes pH, DO, CODCr, total nitrogen, and total phosphorus.

The test data was processed by Microsoft Office Excel.

3. Results and discussion

3.1. Results

3.1.1. Test indicators. 1. The concentration of CODCr in the water of the algae-eating fish test showed a downward trend, which gradually decreased from 153±1.53 mg/L before the algae-eating fish was put into the water, down to 85.3±2.08 mg/L at the end of the experiment; the CODCr in the aeration flow test area also showed a downward trend, which rapidly decreased to 57.3±1.53 mg/L within one week from 153±1.53 mg/L before the aerator, and was approximately flat until 73.6±3.06 mg/L at the end of the experiment. The CODCr concentration of the control water outside the test area started at 169 ± 1.52 mg/L, followed by fluctuations between 175 - 184 mg/L, and the overall remained stable. (Table 1, Figure 2)

Tab 1. The comparison of CODCr concentration among control area (CK), algae-eating algae-eating fish area (FA) and aeration area (AA)

| Test Area        | 0d   | 7d   | 14d  | 21d  |
|------------------|------|------|------|------|
| Concentration (mg/L) | Rate of change (%) | Concentration (mg/L) | Rate of change (%) | Concentration (mg/L) | Rate of change (%) | Concentration (mg/L) | Rate of change (%) |
Fig 2. The comparison of CODCr concentration among control area (CK), algae-eating fish area (FA) and aeration area (AA)

2. The results show that, the total nitrogen concentration of water in the algae-eating fish test area showed an overall decreasing trend, from 7.89±0.08 mg/L before the algae-eating fish was put into the water, down to 3.40±0.06 mg/L at the end of the experiment. The total nitrogen concentration of water in the aeration and artificial streaming technology for remediation of test area also showed a decreasing trend, from 7.72±0.04 mg/L before the aeration, down to 1.97±0.18 mg/L two weeks later. At the end of the experiment, it slightly increased to 2.42±0.12 mg/L. The total nitrogen concentration of the control water began to fluctuate from 8.09±0.07 mg/L to 7.09 ~ 8.18mg/L, remaining stable. (Tab.2, Fig.3)

Tab 2. The comparison of TN concentration among control area (CK), algae-eating fish area (FA) and aeration area (AA)

| Test Area                  | 0d      | 7d      | 14d     | 21d     |
|----------------------------|---------|---------|---------|---------|
|                            | Rate of change (%) | Rate of change (%) | Rate of change (%) | Rate of change (%) |
| Comparison group CK        | 0.00    | -1.16   | 7.01    | 13.25   | 7.09    | 12.33   |
| Algae-eating fish test area FA | 0.00    | 15.66   | 4.15    | 47.41   | 3.40    | 56.82   |
| Aeration area AA           | 0.00    | 55.68   | 1.97    | 74.48   | 2.42    | 68.59   |
3. The total phosphorus concentration in water in the algae-eating fish test area showed an overall decreasing trend, from 0.193±0.002 mg/L before the algae-eating fish was put into the water, down to 0.124±0.002 mg/L at the end of the test and remained unchanged. The total phosphorus concentration of water in the aeration and artificial streaming technology for remediation of test area also showed a decreasing trend, from 0.206±0.004 mg/L before the aerator was put into use, down to 0.116±0.003 mg/L within a week, and remained unchanged until the end of the test. The total phosphorus concentration in the control water began at 0.225±0.001 mg/L, then decreased to 0.184±0.01 mg/L, and remained basically unchanged until the end of the experiment. (table 3, figure 4)

Tab 3. The comparision of TP concentration among control area (CK), algae-eating fish area (FA) and aeration area(AA)

| Test Area                | 0d        | Rate of change (%) | 7d        | Rate of change (%) | 14d       | Rate of change (%) | 21d       | Rate of change (%) |
|--------------------------|-----------|--------------------|-----------|--------------------|-----------|--------------------|-----------|--------------------|
| comparison group CK      | 0.23      | 0.00               | 0.18      | 18.22              | 0.18      | 18.67              | 0.19      | 14.67              |
| algae-eating fish test area FA | 0.19      | 0.00               | 0.16      | 17.96              | 0.12      | 35.58              | 0.13      | 34.20              |
| Aeration area AA         | 0.21      | 0.00               | 0.11      | 47.17              | 0.12      | 43.94              | 0.12      | 44.10              |
4. In addition, DO and pH of dissolved oxygen in the water remain stable both inside and outside the test area during the monitoring period. The concentration of dissolved oxygen in the two test areas rises from about 5mg/L to 8.2-8.9mg/L, and the concentration of dissolved oxygen in the control water outside the test area is 5-6mg/L. The pH of water in and out of the test area is within the normal range of 7-9. (figure 5)

![Fig 5. The comparison of DO and pH among control area (CK), algae-eating fish area (FA) and aeration area(AA)](image)

3.1.2. Sensory indicators. As landscape water, sensory indicators have the greatest impact on the life of the masses, and are also the most concerned by the masses. Specific indicators of eliminating black and smelly water are also defined in the guidelines for urban black and smelly water treatment issued by the state council, among which water transparency is the most important sensory index. Therefore, this experiment also focused on monitoring the sensory targets with transparency.

The water transparency in the algae-eating fish test area showed an overall increasing trend, from 12.7± 0.58cm to 38.3± 2.89cm at the end of the test. The transparency of water in the aeration and artificial streaming technology for remediation of test area also increased significantly, from 12.7± 0.57cm to 39.0± 1.73cm directly within a week, and continued to slowly rise to 48.3± 2.89cm at the end of the test. The transparency of the control water began to be 12.6± 0.57cm and remained basically stable until the end of the experiment. (table 4, figure 6)

| Test Area                        | 0d         | 7d         | 14d        | 21d        |
|----------------------------------|------------|------------|------------|------------|
|                                  | Depth (cm) | Rate of change (%) | Depth (cm) | Rate of change (%) | Depth (cm) | Rate of change (%) | Depth (cm) | Rate of change (%) |
| comparison group CK              | 12.00      | 0.00       | 12.00      | 0.00       | 15.00      | 25.00       | 12.00      | 0.00       |
| algae-eating fish test area FA   | 12.67      | 0.00       | 18.67      | 47.37      | 31.67      | 150.00      | 38.33      | 202.63     |
| Aeration area AA                 | 12.67      | 0.00       | 39.00      | 207.89     | 45.33      | 257.89      | 48.33      | 281.58     |
Fig 6. The comparision of Transparency among control area (CK), algae-eating fish area (FA) and aeration area(AA)

3.2. Discussion

The data above shows that algae-eating fish with aeration and artificial streaming technology for remediation landscape water governance does have control of its pollutants, and the sensory index has a certain effect. However artificial streaming technology control measures work faster than algae-eating fish. Both eventually reach the effect similar to the water quality of ascension and improve sensory standards such as water transparency in the long run.

Both algae-eating fish and aeration flow generation equipment play a significant role in reducing water pollutants and improving water transparency during the test. The results above show that introducing feed algae in water, fish can feeding on algae, suspended particles filter respiration and metabolism in vivo, indirect control of water pollutants concentration index, thus improving water transparency sensory effects, such as the results are consistent with[6], although its effect compared with aeration made flow measures for a long time, but after a period of time also can achieve a similar level of pollutants control effect. However, algae-eating fish have certain requirements on the living environment, which can not play a role in the environment where it is not easy to live or the pollution exceeds its treatment capacity, and may even die, further aggravating the level of water pollution[3]. When applying algae-eating fish to landscape water, it is necessary to choose the water body with light pollution and suitable for its growth, and it is better to match with aeration or other treatment means to maintain the stability of environmental conditions.

In this test, the aeration flow generation equipment can rapidly and significantly reduce the concentration of pollutants including CODCr, total nitrogen and total phosphorus, and rapidly and significantly increase the transparency of the test water body, with significant treatment effect. However, although its environmental adaptability and short-term treatment effect are stronger than those of algae-eating fish, the long-term effect is not much better than biological treatment measures. Moreover, the initial investment of equipment is relatively high. If the equipment without solar power generation is used, its continuous power consumption will significantly increase the operation and maintenance cost. In the actual project application, we should pay attention to the calculation and design of relevant equipment according to the project situation, so as to obtain the most efficient governance effect with the least input.

Whether to use which kinds of means, all should notice if environmental conditions beyond the control measures of treatment and the ability to adapt, processing efficiency will drop dramatically, and even the possibility of governance effect backwards [3], and therefore must be accurately before applying any measures of model calculation, for beyond the capacity of pollution load to match other
processing means to ensure the success of regulation project [7]. At the same time, the mixed use of multiple means should be actively discussed. For example, mixed breeding of mussel and other species can improve the efficiency of pollutant treatment by 10-20% [8], and further expand the idea of ecological treatment.

4. Conclusion
The experiment proved that the ecological control measures in the real application can produce certain effect, but also have some problems need to be solved before entering the promotion, including the effect of governance measures of improvement measures, environmental conditions, tie-in choice, to determine the application environment boundary conditions and so on, in the practical application at the same time also need to the environmental conditions of the project and pollutant load in detailed accounting, ensure the safety and stability of governance systems, and to the improvement of the environment play a role.

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