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Study on Circulating Aquaculture Water Treatment Based on Micro-electrolysis

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We verified the effects of micro-electrolysis technology on the treatment of aquaculture water, and studied the change of the water quality parameters and the growth situation of the fish in the process of micro-electrolysis treatment simulated the aquaculture water in the recirculating aquaculture system, and verified the feasibility of micro-electrolysis technology applied to circulating aquaculture water treatment. At the same time, the growth situation of fish was also tested. The results showed that micro-electrolysis could effectively remove ammonia nitrogen and maintain the stability of water quality parameters. The fish weight kept increasing during the culture, and there was no significant difference compared with the theoretical increase.

1. Introduction

In the recirculating aquaculture system, the rapidly accumulation of TAN (total ammonia nitrogen) is caused by the decomposition of fish excreta and food residues. In the aquaculture of the recirculating water system, the breeding density is high and the water volume is limited, which will lead to the rapidly deterioration of the water quality of the aquaculture, and this problem is particularly important in circulating water culture. In addition, the nitrification efficiency of the biofilter in seawater is lower than in fresh water. Since non-ionic ammonia and nitrite are highly toxic to fish, it is necessary to adopt new techniques to avoid the accumulation of these toxic compounds and to achieve the effective removal, which is necessary to consider the reuse of aquaculture water to reduce environmental problems and save operating costs. The water treatment technology is an important part of the cycle of aquaculture and the key factors to determine the success of farming. We use the water treatment technology combined with the micro-electrolysis to carry out research on recycled water.

2. Materials and methods

2.1 Experimental materials and equipment

The cultivation object is Gifu Tilapia. Granularity aquaculture feed (fish meal, summer grain, peanut money, squid thorn, high-gluten flour are as the main raw material). UV-visible spectrophotometer, Seven-Multi-type pH / ORP / Conductivity general-purpose tester, BSA822 electronic balance; sterile console, autoclave, constant temperature incubation, PVM-3 multi-filter, AP series of vacuum-free without candle diaphragm, water bath, thermometer (-4-50 °C), portable turbidity meter (HACH2100P, Hach), stabilized voltage supply, UV, titanium-based platinum electrode; glutamate acid deaminase, transaminase and carbonic anhydride kit.

2.2 Testing apparatus

The recirculating aquaculture system based on micro-electrolysis is shown in figure 1. The size of the fiberglass aquaculture pond is φ800mmx750mm; the flow rate of the catastrophe splitter is 1000L / h; the combined electrolytic cell (the outer cylinder size is φ300mm, the inner cylinder size is φ200mm, the power of two ultraviolet lamps is 16w, the size of electrode slice is 25x15cm); The size of the buffer tank is 1000x300x500mm, activated carbon filter (the high is 1250mni, in which the quartz sand layer is 150cm, the fine carbon layer is 900mm).

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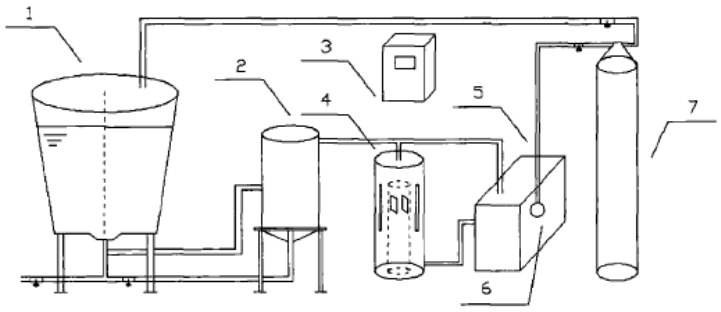

Figure 1: Micro-electrolysis test system device diagram

1, breeding pond 2, pot spin separator 3, drawing box 4, combined electrolysis cell 5, bulking tank 6, pump 7, activated carbon filter

2.3 Experimental methods

1) Preparation of aquaculture water

In the industrial circulating water channel, before flowing into the pond, the sea water needed to add a certain amount of fresh water to adjust the water temperature, and the sea water salinity was about 25 ‰ or so after adjusting. Therefore, the aquaculture water in this experiment was prepared by adding seawater into tap water so that the salinity reached 25 ‰, the pH value was 7.30-7.60, and the fry was placed in the pool after 24 hours. The ammonia concentration of simulated wastewater reached 5mg / L or so by adding 10g chlorination.

2) Tilapia domestication

Gifu Tilapia is a good stock that after years of efforts, the Philippine aquaculture experts use the traditional breeding methods combined with bio-engineering technology to cultivate and the breeding materials are four species of Asian Nile tilapia and four species of European Nile tilapia, named Nile tilapia "Jifu strain." The time for domesticating the Tilapia used for testing is 5 days. The specific method of domestication is in a recirculating aquaculture system (the size of the culture pond is φ2m, and the depth of water is 60cm), the salinity is improved 1 ‰ per day to 25 ‰. The fish is fed according to 1% of the fish weight during the domestication. The daily water exchange rate is 5%, and the salinity should be maintained stable. Aquaculture pond uses the aerated poly to increase oxygen, and the water quality indicators during the days is that the water temperature is 23 ~ 27 ℃, pH is 7.5 ~ 7.9, and dissolved oxygen is 6.0 ~ 9.0mg / L. The body weight of the fish was determined after the domestication was completed, and the fish was transferred into the experimental pool for breeding experiment.

3) Tilapia feeding

There were 21 tilapias in each pool. The average weight was 250 ± 5g, and the daily feeding amount was 3% of the weight. After that, the feed amount was increased according to the increase of the theoretical weight, and the feeding time respectively is 9: 00, 13: 00 and 18:00. The rest of the materials timely remove and weigh.

4) Electrolytic conditions

According to the "hypochlorite steel generator GB 12176-90", when 1A·h of electricity went through the electrolyzer in diaphragmless electrolytic, the theoretical production of available chlorine was a certain value. At the same time, according to the Faraday's law of electrolysis, the electrolytic conditions in the second chapter was amplificated to determine the electrolytic condition of this experiment was (15V, 2.5A), the ratio of electrolysis to direct reflux was 1: 2, and the electrolysis time was 5h / day (9: 00 ~ 14: 00).

5) Water quality index detection

Three sampling points were set in the system. The sampling point 1 was located in two aquaculture ponds. The sampling point 2 was located at the outlet of the electrolyzer. The sampling point 3 was located in the buffer tank. PH and ORP (redox potential) were determined by multifunction Ph. The residual chlorine was determined by UV spectrophotometri. The ammonia nitrogen, nitrite, nitrate were determined by using the national standard method, and the system changed 5% water every day.

6) Tilapia growth situation

The Tilapia weight growth during culture can be expressed as follows:

$$W_t = \left[W_0^{0.453} + 0.00512 \times e^{0..09Temp(\mathrm{B°C})} \times days\right]^{2.207} \quad (1)$$

W0 was the initial weight of tilapia, and Wt was the tilapia weight after t days.

2.4 Data processing

The drawing was completed by using excel software to analyze, SPSS was used for analysis of variance, the results was expressed as mean ± standard deviation.

3. Results

3.1 The change of water quality parameters of simulated circulating aquaculture system

Before the aquaculture experiment, the chlorinated ingot was added to the sea water to make it reach the concentration of 5mg / L. The electrolysis time and electrolysis power were determined by simulating the change of the water quality parameters and the removal efficiency of ammonia nitrogen during the electrolysis of the wastewater. The voltage was 15V, the current was 2.5A, the proportion of electrolysis part and direct reflux part was 1: 2, and the electrolysis time was 3h. The change of pH, ORP, residual chlorine, ammonia nitrogen, nitrite nitrogen and nitrate nitrogen in the aquaculture water after electrolysis were shown in Figure 2 to Figure 7.

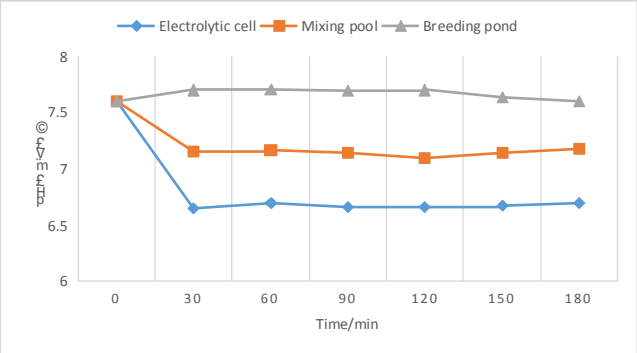

Figure 2: The change of pH during the simulated electrolysis of aquaculture water

From Figure 2, it can be seen that the pH decreased rapidly to 6.78 when the pond water flowed through the electrolyzer. When the water in electrolysis cell was discharged into the buffer tank, the pH was kept at 7.15 due to mixing with the non-electrolyzed aquaculture water. After the buffer water went through the activated carbon filter, the pH value is rapidly increased because of the adsorption of the activated carbon, but it will be slightly lower than that of the previous culture pond. In general, the pH of the pond water decreased from 7.68 to 7.53 in the process of electrolysis. So the electrolysis will lead to pH reduction in the breeding pool, with the prolongation of the electrolysis time, pH value decreased more obvious. In the actual breeding test, the baking soda should be added or the medical stone should be put in the buffer pool to adjust the pH of breeding water to ensure the stability of pH.

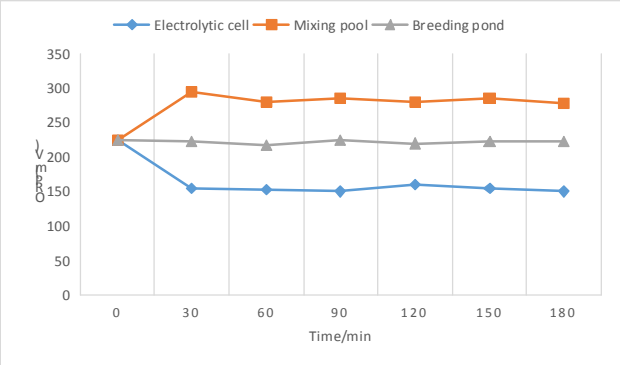

Figure 3: The change of ORP during simulated seawater electrolysis

As shown in Figure 3, the ORP was reduced to about 170 mV when the pond water flowed through the electrolytic cell. When the electrolytic cell effluent enters the buffer slot, ORP remained at about 275 mV due to mixing with the untreated aquaculture water; After the buffer water went through the activated carbon filter, ORP decreased rapidly because of the adsorption of the activated carbon, but the ORP in original breeding

pool remained basically the same; overall, in the electrolysis process, ORP of the breeding pool water remained at 231mV or so. As a result, the ORP of the breeding pool is almost constant during the electrolysis.

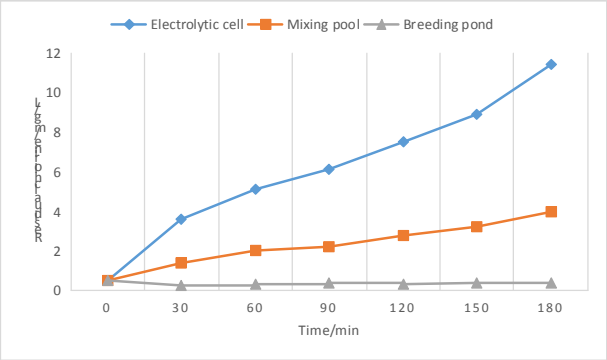

Figure 4: Change of residual chlorine in the process of simulated aquaculture water electrolysis

As shown in Figure 4, the effective chlorine concentration increased rapidly when the aquaculture pond water flowed through the electrolytic cell, especially in the first 30min, the highest rate reached 6.45mg / L, then kept rising trend, and reached 11.34mg / L at 180min. When the effluent of the electrolyzer flowed into the buffer pool, the residual chlorine increased from the 24mg/ L after leakage because of mixing with the non-electrolysis of the pond water. After the buffer water went through the activated carbon filter, the residual chlorine quickly dropped to about 2mg / L because of the adsorption of the activated carbon. From the overall view, the residual chlorine of the aquaculture pond water remained l ~ 0.5mg /, which lower than the tilapia Semi-lethal concentration.

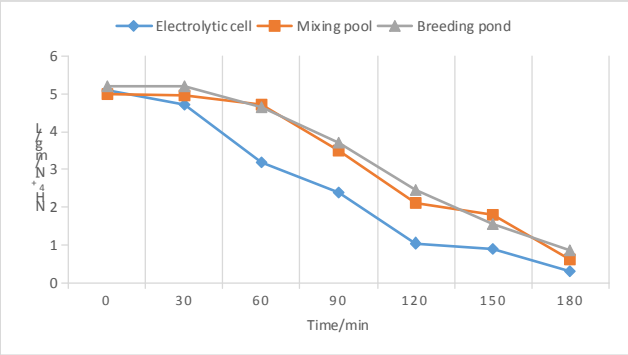

Figure 5: The change of ammonia nitrogen in the process of simulated seawater electrolysis

As shown in Figure 5, when the simulated wastewater flows through the electrolytic cell, the combination of electrolysis and UV produces dwarf radicals and chlorine radicals as well as direct electrochemical oxidation, which accelerate the removal of ammonia nitrogen. The concentration of ammonia in 120 min rapidly decreased from 5.089mg / L to 1.026mg / L. The concentration of ammonia nitrogen in buffer pool and the culture pond changed little in 60min, but decreased rapidly after 60min, and decreased to 0.7mg / L in 180min. One-way ANOVA was used to analyze the concentration of NH3-N in the culture water at different time points. The results showed that the concentration of NH3-N in the buffer pool and the culture pond was not much different, but the concentration of NH3-N was higher than that in the effluent of electrolytic cell, which indicated that the removal of NH3-N was mainly due to the direction electrolysis oxidation in the electtrolyzer. But the concentration of available chlorine was low in the bulking tank, and the indirect electrochemical oxidation was weak, which had no effect on the removal of NH3-N. In general, 5mg / L ammonia nitrogen in the culture pond rapidly reduced to below 1mg / L, which will not have an impact on the normal growth of fish.

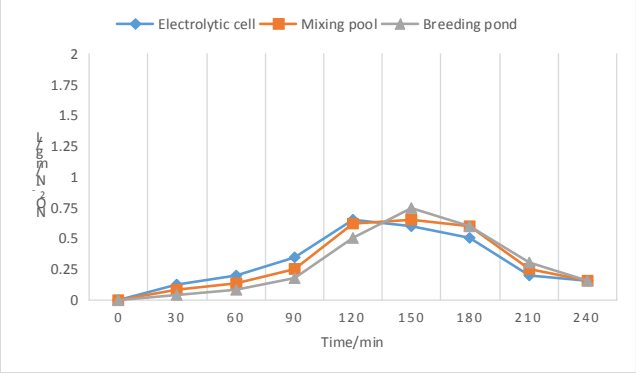

Figure 6: The change of nitrite nitrogen in the process of simulated seawater electrolysis

As shown in Figure 6, the concentration of nitrite increased with the prolongation of electrolysis time when the aquaculture water flowed through the electrolyzer, and reached the maximum at about 150 min, which was about 0.76 mg / L. As the electrolysis time continued to prolong, the concentration of the nitrite started to decrease rapidly, and decreased to 12mg / L at 240min. The change of nitrite nitrogen in the buffer pond and culture pond changed almost the same as in the electrolytic cell, and the nitrite nitrogen concentration in the culture pond was always lower than that in the electrolyzer and buffer pool in the first 150min, that is, the denitrification of the part of the nitrate occurred in this process.

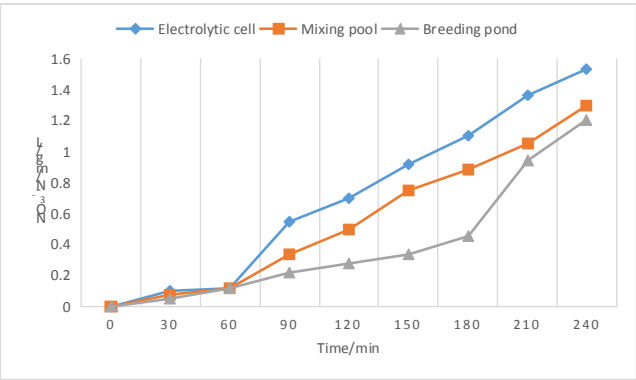

Figure 7: The change of NO3-N in the process of simulated seawater electrolysis

It can be seen from Figure 7 that the concentration of ammonia and nitrogen in the culture ponds, electrolyzers and buffer pools increased during the first 60 min in the water treatment of the combination of electrolysis and UV, but the difference was not significant. With the prolongation of the time, the concentration of NO3-N of the H sampling location showed a certain differences that it was the highest in the electrolyzer, followed by in the bulking tank and it was lowest in culture pond. The concentration of NO3 - N in the culture pond reached 1.23mg / L at 240min, while the concentration of NO3 - N at 300mg / L did not affect the growth of the culture objects in the actual breeding process.

3.2 Increase of the fish weight during breeding

At the beginning of the breeding, the fish were sampled at random in each culture pond and the body weight was measured. The body weight was then measured every 10 days in the same manner, and the theoretical body weight gain of the fish was calculated according to 2-1. The result was shown in Figure 8:

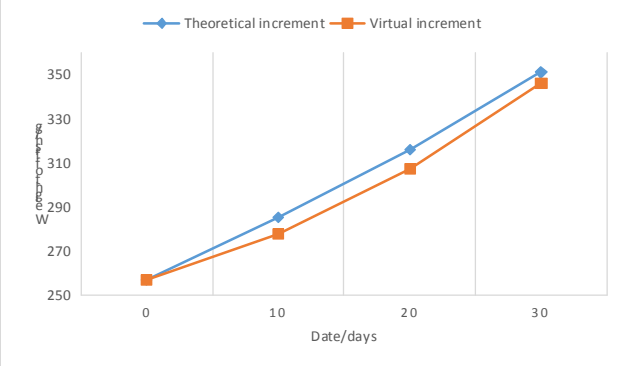

Figure 8: Body weight gain of tilapia during culture test

During the 30-day culture period, tilapia's body weight kept increasing, but the growth was less than the theoretical growth. At the end of the culture, tilapia weight was 9.3 ± 10g, which was lower than the theoretical value of 12g. This is partly due to the fact that the water temperature can not be maintained at 28 °C, and the temperature of the water gradually decreased with time, which affects the feeding of tilapia.

4. Conclusion

Micro-electrolysis can effectively remove the ammonia in aquaculture water, but at the same time will cause a short-term increase in the concentration of nitrite. In addition, during the electrolysis process, the ORP of aquaculture water fluctuated in small amplitude, but it did not affect the fish. The residual chlorine concentration in water gradually decreased with the prolongation of the culture time, and the pH value decreased with the prolongation of the electrolysis time, which needed to regularly adjust. The micro-electrolysis did not affect the feeding and growth of fish.

Reference

Deng S., Li D., Yang X., Xing W., Li J., Zhang Q., 2016, Biological denitrification process based on the Fe (0)–carbon micro-electrolysis for simultaneous ammonia and nitrate removal from low organic carbon water under a microaerobic condition. Bioresource Technology, 219, 677-686.

Han Y., Li H., Liu M., Sang Y., Liang C., Chen J., 2016, Purification treatment of dyes wastewater with a novel micro-electrolysis reactor. Separation and Purification Technology, 170, 241-247.

Liu L., Liu Y.H., Wang L.N., Li T., Cai H.Y., 2015, Preparation of iron carbon micro-electrolysis materials and research on its continuous treatment process of actual wastewater, Ind. Water. Treat, 35, 60.

Qi Y., He S., Wu S., Dai B., Hu C., 2015, Utilization of micro-electrolysis, up-flow anaerobic sludge bed, anoxic/oxic-activated sludge process, and biological aerated filter in penicillin G wastewater treatment. Desalination and Water Treatment, 55, 6, 1480-1487.

Wei X., Li D., Li J., Hu Q., Deng S., 2016, Nitrate removal and microbial analysis by combined micro-electrolysis and autotrophic denitrification. Bioresource technology, 211, 240-247.

Xu X., Cheng Y., Zhang T., Ji F., Xu X., 2016, Treatment of pharmaceutical wastewater using interior micro-electrolysis/Fenton oxidation-coagulation and biological degradation. Chemosphere, 152, 23-30.

Zhang Q., 2015, Treatment of oilfield produced water using Fe/C micro-electrolysis assisted by zero-valent copper and zero-valent aluminium. Environmental technology, 36(4), 515-520.