Study on the Removal of Nitrogen-containing Waste outside the Aquaculture Pond by the Method of Electric Flocculation and Quasi Circulating Aquaculture

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Abstract. When the waste containing ammonia nitrogen is removed by electric flocculation circulating aquaculture, not only the colloidal impurities and suspended impurities are coagulated and precipitated, but also a variety of pollutants and bacteria in the water can be removed due to the oxidation of the anode and the reduction of the cathode. In this project, PWM (pulse width modulation) technology is used to overcome the power consumption problem of traditional electric flocculation method, high-voltage pulse and anode-cathode pole exchange technology is used to overcome the iron consumption and plate passivation problem, and echelon potential method is used to solve the difficulty of plate exchange. Compared with the traditional chemical and biological treatment technology, electrocoagulation can ensure the sustainable development of aquaculture without adding oxidants, flocculants and other chemicals. At present, electronic technology and Internet of things technology are used in aquaculture fields to monitor the water quality data in the pond and control the growth of aquaculture organisms in the most suitable environment in real time, so as to increase income, reduce human power and save water and electricity. Therefore, with mature sensing technology, IOT, IM, cloud computing, big data and AI, we can build an intelligent aquaculture production, marketing and digital service system to improve the overall production efficiency, energy and quality, and accelerate the transformation of aquaculture industry.

1. Introduction

With the rapid development of aquaculture industry and the continuous improvement of aquaculture technology, the scale-up aquaculture is expanding, the density of aquaculture is increasing, the output per unit area is increasing, along with the increase of artificial feed, the ecological balance of aquaculture water body has brought a huge impact, under such a high load, how to maintain the ecological balance of water body has become the key to aquaculture. Reasonable control of ammonia nitrogen content in the pond has become a key factor for the success of aquaculture. In the process of aquaculture, we often encounter the problem that the ammonia nitrogen in the pond is too high. Especially in the high-density intensive cultivation mode, the ammonia nitrogen in the aquaculture water will gradually accumulate. When its concentration reaches a certain value, it will not only have a direct toxic effect on fish, but also induce a variety of diseases and become one of the water factors limiting the normal growth of fish. [1,2]
1.1 Formation of ammonia nitrogen
There are three main sources of ammonia nitrogen:

a) Large number of proteins contained in the excreta of aquatic animals, applied fertilizers, residual baits and animal and plant corpses are decomposed by microorganisms in the pond to form amino acids, and then further decomposed into ammonia nitrogen.

b) When the oxygen is insufficient, denitrification occurs in the water, and nitrites and nitrates decompose under the action of denitrifying bacteria to produce ammonia nitrogen.

c) Through gills and urine, crustaceans can discharge ammonia nitrogen to the water body through gills and antennae gland, so as to avoid ammonia poisoning in the body.

1.2 Harm of ammonia nitrogen to aquatic animals
There are three main sources of ammonia nitrogen:

a) Ammonia nitrogen poisoning: ammonia nitrogen exists in water in two forms, one is ammonia (NH3), also called non ionized ammonia, which is fat soluble and toxic to aquatic organisms. The other is ammonium (NH4 +), also called ionic ammonia, which is non-toxic to aquatic organisms. When ammonia (NH3) enters aquatic organism through gill, it will directly increase the burden of ammonia nitrogen excretion of aquatic organism, the concentration of ammonia nitrogen in blood will increase, blood pH With the increase of H, the activities of many enzymes in aquatic organisms are inhibited, and the oxygen carrying capacity of blood is reduced, the gill epidermis is destroyed, the oxygen carrying capacity of blood is reduced, which leads to the poor exchange of oxygen and waste and suffocation.

b) Harm of ammonia nitrogen to aquatic organisms: chronic poisoning hazards include: decreased food intake, slow growth; tissue damage, reduced oxygen transport between tissues. Both fish and shrimp need to carry out ion exchange (sodium, calcium, etc.) with the water body. Too high ammonia nitrogen will increase the permeability of gills, damage the ion exchange function of gills, make aquatic organisms in a long-term state of stress, increase the susceptibility of animals to diseases, reduce growth speed, reduce reproductive capacity, reduce the viability of eggs, and delay spawning and reproduction.

2. Aquaculture - ammonia nitrogen removal technology
In the breeding process, the metabolites and undigested nutrients produced by the feed after being used by the breeding organisms are discharged into the water body, resulting in a large amount of nutrients and various organic and inorganic substances in the water body, which not only affects the water quality of the breeding water, but also pollutes the surrounding environment. [3]

The removal of nitrogen-containing waste from traditional aquaculture water can be divided into two ways, one is outside the aquaculture pond and the other is inside the aquaculture pond: as shown in figure 1.

2.1 Removal of nitrogen-containing waste outside the aquaculture pond
The methods for removal of nitrogen-containing waste outside the aquaculture pond include: (1) treatment by soil pond or reservoir; (2) treatment by combination of solid removal and nitrification.

The treatment method of using soil pool or reservoir is to directly discharge the aquaculture wastewater to the treatment pool, and improve the water quality and reuse after natural physical, chemical and biological treatment for hours to days. The change of phytoplankton and biofacies could not be expected.

2.2 Removal of nitrogen-containing waste from aquaculture ponds
The ammonia nitrogen in aquaculture water can be removed by three ways: photosynthetic self-support of algae, conversion of ammonia nitrogen into nitric acid nitrogen by self-support bacteria and conversion of heterotrophic bacteria into biomass by ammonia nitrogen. In the aquaculture pond, the nitrogen-containing waste in water can be removed by using the technology of epiphyton and bio
flocs. These two methods can also be used as the source of aquaculture biological food and reduce the use of fish oil and fish meal.

Figure 1. Traditional removal method of ammonia nitrogen in aquaculture.
1 Removal of nitrogenous waste outside the culture pond
2 Removal of nitrogenous waste from the aquaculture pond.

3. Removal of nitrogen-containing waste from aquaculture ponds by electrocoagulation
The reaction principle of electrocoagulation is to take iron, aluminum and other metals as anodes. Under the action of DC power supply, the anodes are eroded to produce Fe, Al plasma. In the process of hydrolysis, polymerization and ferrous oxidation, the anodes develop into hydroxides, which make the colloidal impurities and suspended impurities in wastewater agglomerate and precipitate and separate. At the same time, the charged pollutant particles swim in the electric field, and part of its charge is charged by the electrode Neutralization promotes its destabilization, condensation and precipitation. [4-6]

When the aquaculture water is treated by electrolytic flocculation, it can not only coagulate and precipitate the colloidal and suspended impurities, but also remove many pollutants in the water due to the oxidation of anode and reduction of cathode. Electrocoagulation pretreatment: under the action of external direct current, the iron plate of anode reacts with oxidation to form Fe$^{2+}$, which polymerizes withOH produced by cathode reduction to form Fe(OH)$_2$ flocculent with strong adsorption capacity, which adheres the suspended solid matter in sewage and sinks; meanwhile, the hydrogen micro bubble produced by cathode and oxygen micro bubble produced by anode during electrolysis of water It will also drive the floating of the solid suspension, so as to achieve the purpose of separating the suspension and purifying the water quality.

3.1. Problem analysis: the aquaculture industry in Taiwan is facing the problems of limited water and soil resources and relatively high production costs such as labor:
  a) Poor production environment and infrastructure need to be strengthened.
  b) Lack of exclusive management law source, there are many and miscellaneous applicable law sources.
  c) Excessive utilization of water and soil resources and high-density aquaculture may lead to the risk of drug residues.
  d) Climate change makes the frequency of natural disasters increase day by day, so the industry needs to plan and adjust its development strategy.
e) Investment in scientific and technological research and development is decreasing day by day, reducing the competitive advantage of the industry.

f) The low degree of mechanization and the aging of the breeding population lead to the expansion of the manpower gap.

3.2. Overview of previous studies:
The electric flocculation circulating aquaculture method has:
   a) Low investment cost
   b) Low operating cost
   c) Low maintenance cost
   d) No need to add any chemicals
   e) Small floor area
   f) Simple operation

3.3 Advantages of high degree of automation
The application and development of traditional electrocoagulation are limited by the following disadvantages.
   a) High power consumption
   b) High iron consumption
   c) Plates are easy to passivate
   d) Difficulty in plate changing

3.4. Key points to be solved: advantages of electric flocculation circulating aquaculture
   a) Reduce investment costs
   b) Reduce operating costs
   c) Reduce maintenance and repair costs
   d) No need to add any chemicals
   e) Small footprint reduction
   f) Operation simplification
   g) Improve automation

4. Complete intelligent aquaculture and fishery environment

4.1. With the goal of intelligent farming and fishery environment[7]
   a) The removal of nitrogen-containing waste outside the culture pond by the electric flocculation circulating water culture method. When the culture water is treated by electrolytic flocculation, it not only coagulates and precipitates the colloidal impurities and suspended impurities, but also can remove a variety of pollutants in the water due to the oxidation of the anode and the reduction of the cathode.
   b) Electrocoagulation pretreatment: under the action of external direct current, the iron plate of anode reacts with oxidation to form Fe2+, which polymerizes with OH- produced by cathode reduction to form Fe(OH)2 flocculent with strong adsorption capacity, which adheres the suspended solid matter in sewage and sinks; meanwhile, the hydrogen micro bubble produced by cathode and oxygen micro bubble produced by anode during electrolysis of water It will also drive the floating of the solid suspension, so as to achieve the purpose of separating the suspension and purifying the water quality.
   c) In this study, PWM (pulse width modulation) technology is used to overcome the power consumption problem of the traditional electric flocculation method, and high-voltage pulse and positive and negative pole exchange technology are used to overcome the problem of iron consumption and plate passivation. To solve the problem of plate replacement, echelon potential method is used.
   d) It is believed that the use of electrocoagulation can effectively solve the problem of high
efficiency aquaculture. Compared with the traditional chemical and biological treatment technology, electrocoagulation can ensure the sustainable development of aquaculture without adding oxidants, flocculants and other chemicals.

4.2 The second year aims at intelligent aquaculture and fishery environment

   a) Trend chart analysis; provide real-time monitoring, map and image real-time monitoring, and display of the geographic area of Gangchi at a time.
   b) Multi-function and high efficiency integration of all sensors; suitable for water quality monitoring of fresh water, sea water and groundwater, providing various values.
   c) Alarm automatically to deal with the crisis in real time; in case of abnormality such as low dissolved oxygen in water, send out a message automatically or only alarm.

4.3 Building intelligent aquaculture

Taiwan's information and electronics industry, which has been deeply cultivated for ten years, has become a strong and stable industrial economy with international status, and its transfer to other engineering technology industries has achieved remarkable results. The research and development of the Internet of things technology is applied to the aquaculture field to monitor the water quality data in the pond, and to transmit the data to the control host for real-time control, so as to ensure that the breeding organisms grow in the most suitable environment, so as to increase the income, reduce the human power consumption and save the water and electricity. Therefore, based on Taiwan's existing advantages in aquaculture breeding and breeding technology, by developing increasingly mature sensing technology, IOT, Im, cloud computing, big data analysis and artificial intelligence (AI) And other key technologies can build intelligent aquaculture production and marketing and digital service system to improve the overall production efficiency, quantity and quality of aquaculture, and accelerate the pace of aquaculture industry transformation. [8]

5. Conclusion

In this study, PWM (pulse width modulation) technology is used to overcome the power consumption problem of the traditional electric flocculation method, and high-voltage pulse and positive and negative pole exchange technology are used to overcome the problem of iron consumption and plate passivation. To solve the problem of plate replacement, echelon potential method is used. It can effectively solve the problem of high efficiency aquaculture by using the method of electrocoagulation to remove nitrogen-containing waste outside the aquaculture pond. Compared with the traditional chemical and biological treatment technology, electrocoagulation can ensure the sustainable development of aquaculture without adding oxidants, flocculants and other chemicals.

At present, electronic technology and Internet of things technology are applied in aquaculture fields. Sensors are set up in aquaculture ponds to monitor the water quality data in the ponds and control the growth of aquaculture organisms in the most suitable environment in real time, so as to increase income, reduce human power and save water and electricity. Therefore, with mature sensing technology, IOT, Im, cloud computing, big data and AI, we can build an intelligent aquaculture production, marketing and digital service system to improve the overall production efficiency, energy and quality, and accelerate the transformation of aquaculture industry.

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