Water Treatment Experimental Researches for Microbubble Flotation, Coagulation Deposition and Microbubble Coagulation Floatation

Zhekun Li, Yongren Zhang, Yuehong Han, Kanglin Xie, Yujin Fan, and Wenli Shi

***Abstract*—**The water is very important for human life. This paper studied the methods of Microbubble Flotation, Coagulation Deposition, Microbubble Coagulation Floatation to process the water from Dianchi Lake in China, and explored the advantages and disadvantages of the three methods. It provides good reference for better governance of Lakes and cleaning dirty water.

***Keywords*—**Water Treatment, Microbubble Flotation, Coagulation Deposition, Microbubble Coagulation Floatation

I. Introduction

THE Dianchi Lake is a typical eutrophication of lakes in China. For a long time, scholars at home and abroad have given high attentions to the Lake. It is the human activity that brings the Dianchi Lake be pollution crazily and accelerates eutrophication process, mainly recently manifested in two aspects. The one was in the 1970s to produce 70% of the area be "enclosing sea for fields", completely destroyed the original shallow wetlands, and made the Dianchi Lake have a high flood control pressure. For flood control, 84% of the lakeside zone built levees, which made the terrestrial ecosystem was almost completely isolated from aquatic ecosystem [1]. The two was Kunming's industries in the late 1970s began to accelerate development and were most of metallurgical and chemical fertilizer industries [2]. In the late of 1980s, factories had been around the Dianchi Lake, and produced large amounts of pollutants. Due to the lack of the environmental protection consciousness and relative policies, these pollutants drained directly into the Dianchi Lake, the water quality deteriorated rapidly.

The Dianchi Lake water is selected as our experiment researches on self-made testing apparatus, microbubble flotation and coagulation deposition are compared with each other, the turbidity and COD_{Mn} are measured as experimental indexes.

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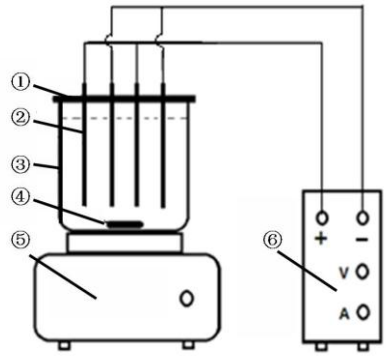
II. Preparation Of Experiments

Experimental water from the Dianchi Lake, the COD_{Mn} and turbidity measurement data are shown in the Table Ⅰ.

TABLE I
THE DIANCHI LAKE ORIGINAL WATER MEASUREMENT DATA

COD_{Mn} (mg/L)	Turbidity (NTU)	pH
11.8	46.2	8.4

Experimental device, as shown in Fig. 1, uses 1000 ml beaker as microbubble flotation tank. On the top of the beaker there are four parallel sets of size 150 mm x 50 mm x 2 mm plate electrode, the distance between them can be adjusted according to the requirements. The electrode plates immerse 100 mm deep in the water. A DC regulated power supply as power source, which can provide 0~30 V voltage, maximum current is not more than 5 A. A magnetic stirrer is placed in the beaker, which is used to change the flow situation in the beaker and make microbubbles and flocculant generated by electrolysis fully spread. [3]



① Support, ② Electrode, ③ Beaker, ④ Stirrer, ⑤ Magnetic Stirrer, ⑥ DC Power Supply

Fig. 1 Microbubble flotation device made by ourselves

In the electrolysis microbubble flotation, the anode can form flocculating positive metal ions [4]. Microbubble flotation with

soluble anode in the electrolytic reaction will be dissolved gradually, so the electrode needs to be replaced after used a certain period. If the microbubble flotation uses insoluble anode in the electrolysis process, the insoluble anode will not need to change. The stainless steel in the process of electrolysis will only separate out very small amounts of iron, chromium, nickel ions, so the form of the flocculant ability is negligible. Sometimes stainless steel can be selected as electrode materials.

III. MICROBUBBLE FLOTATION EXPERIMENT

Take 1000 mL water, not adding the NaCl, don't change the pH value. The current density is of 4 mA/cm^2, electrode spacing is of 10 mm and electrolytic time is of 20 min, let stand 20 min and then measure the COD_{Mn} and turbidity. Test measuring data are as shown in Table Ⅱ.

TABLE II
MICROBUBBLE FLOTATION TEST RESULTS

Test index	Value (mg/L)	Removal Rate (%)
COD_{Mn}	10.1	14.41
Turbidity	34.8	24.67

The test results show that the pure microbubble flotation treatment of the Dianchi Lake water, the removal effect of COD_{Mn} and turbidity is not very good and the removal rates are low. The reason is in the flotation process, insoluble anode cannot produce and form much metal ion flocculant. Without the cohesion function of flocculant, only larger diameter of algae can be adhere out by microbubbles from the water, and the smaller diameter particles and colloid cannot be condensed to form larger flocs, therefore cannot effectively be adhered by microbubbles and buoyed up. So in the use of insoluble anode sometimes it shall generally add dosing flocculants, it can improve the effectiveness of microbubbles flotation.

IV. COAGULATION DEPOSITION EXPERIMENT

Coagulation deposition and microbubble flotation have basically same flocculation mechanism. The coagulation deposition makes particles and colloid form flocs by the roles of compressing electric double layers, electric neutralization. In the microbubble flotation, the flocculants is produced by the electrolysis, flocs are buoyed up out of the water by microbubble. In coagulation deposition, the flocculant is directly added and flocs fall down by the gravity. [5]

There are many kinds of flocculant, inorganic flocculants such as aluminum salt and iron salt do have electric neutralization and can form thawless complex, and their hydroxyl can effectively adsorb organic compounds. This experiment used polyaluminium chloride as flocculant, its dosage demand for water temperature is not much, and the pH range is of 5-9, condensation effect is good. Choose Al2O3 content is 30% of polyaluminium chloride in the experiment.

Take 4 of 1000 mL of original water, dosing quantity of polyaluminium chloride respectively 30 mg/L, 60 mg/L, 90 mg/L, 120 mg/L, 150 mg/L, magnetic stirrer (300 r/min) for 2 min, then slowly stir 60 (r/min) 5 min, and then keep quiet place. In the process of magnetic stirrer stirring, it is observed:

- Dosing amount to 30 mg/L in the water produced a large number of micro flocs suspended in the water, after 60 min they are still suspended in the water, no obvious sink;
- Dosing amount to 60 mg/L in the water also produced a large number of micro flocs, but after 60 min, basically sink, but the sediment accounts for a larger volume and if slightly shaking the small flocs will spread;
- Dosing amount in more than 90 mg/L in the water quickly produced flocs, and the flocs increased gradually sinking speed, after 60 min the water is clear, but there is still a very small amount of suspended solids.
- It also found that the more quantity of polyaluminium chloride is added in the water, the faster and the more of flocculate is produced, the faster deposition rate is, after deposition the smaller size of floc is, the clearer of the water is.

Let stand for 60 min and then measure the COD_{Mn} and turbidity. Test results are shown in Fig. 2.

It can be seen in Fig. 2:

- Dosing amount to 60 mg/L, the removal rates of COD_{Mn} and turbidity are 38.14% and 68.83% respectively;
- As dosing quantity is 90 mg/L, the removal rates of COD_{Mn} and turbidity are 47.46% and 86.36% respectively, they increase obviously;
- When dosing quantity increased from 120 mg/L to 150 mg/L, the removal rates of COD_{Mn} and turbidity increased only 1.69% and 1.08% respectively, they are 52.54% and 94.37% respectively.

This suggests that as the dosing quantity is little, the coagulation deposition effect is limited, and with the increase amount, the removal efficiency is more and more obvious, but the removal will rise slowly after passing a certain point..

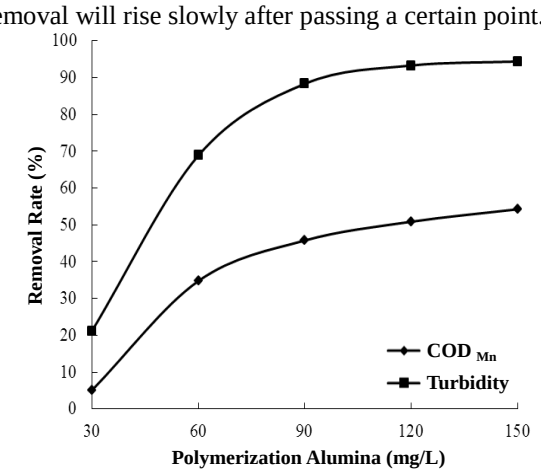


Fig. 2 Experiment of coagulation deposition

Although, the more polyaluminium chloride dosing is the more beneficial for remove of COD_{Mn} and turbidity, too much is not better. When flocculant is close to the optimal dosing quantity, its influence on the removal rates of COD_{Mn} and turbidity will not be obvious. In addition, the excessive flocculant dosing will make particles and colloid adsorb excess positive charge, become a stable state and cause the colloid protection phenomenon. It will suspend a lot of difficult sinking small flocs in the water, the removal rates of COD_{Mn} and turbidity are not high, and the flocculant is waste.

V.4 MICROBUBBLE COAGULATION FLOTATION EXPERIMENT

Microbubble coagulation floatation is a good technology for

processing the algae in the water, the algae removal efficiency is significant [6][7]. Take 1000 mL water, add 60 mg/L of polyaluminium chloride, stir magnetic stirrer (300 r/min) 1 min, use the stainless steel plate as electrode, the microbubble coagulation floatation experiment was carried out in the current density of 4 mA/cm^2, under the conditions of electrode spacing of 10 mm, electrolytic time of 20 min, let stand 20 min and then measure the removal rates of COD_{Mn} and turbidity as shown in Table Ⅲ.

TABLE Ⅲ
EXPERIMENTAL RESULTS

Test index	Microbubble Coagulation Flotation
COD_{Mn} Removal Rate (%)	59.32
Turbidity Removal Rate (%)	96.32

It can be seen in Table Ⅲ, in microbubble coagulation floatation the removal rates of COD_{Mn} microbubble flotation are good. The flocculant in flotation process plays a important role. To make the particles and colloid form flocs that can be adhered by microbubbles and be buoyed easily.

VI. WATER TREATMENT EQUIPMENT

After experimental researches of water treatment, the results provide effective reference for designing better water treatment equipments. These equipments should include water input, pH adjusting, adding flocculant, stirrer, water output, dirt removing, electrode, water treatment vessels, electrode cleaner, vessel cleaner, power supply system, electrode change device, and so on. These water treatment equipments can combine a system which include more than one above water treatment methods, or change its combination according to the requirements. The device of adding flocculant will control the dose according to the amount of water and the kind of water. The microbubble flotation device made by ourselves, as shown in Fig.1, is a kind of simple prototype of water treatment equipments for cleaning the algae from water.

VII. CONCLUSIONS

In this paper stainless steel electrode is used for microbubble flotation experiments. Coagulation deposition experiment had been carried out by using polyaluminium chloride when adding different doses of flocculants. The removal rates of COD_{Mn} and turbidity, and the optimal treatment effect had been studied. The effects of three methods of water treatment, microbubble coagulation floatation, microbubble flotation and coagulation deposition, are analyzed. Especially under the same experimental conditions, microbubble coagulation floatation experiment has been carried out and compared with others. The conclusions are:

- Within a certain range, the more flocculant dosing, the higher removal rates of COD_{Mn} and turbidity are. But adding the quantity more than a specific value, the removal rates of COD_{Mn} and turbidity change smaller.
- The flocculating in the process of reducing COD_{Mn} and turbidity directly affects the high and low of removal rates.
- The flocculation and floatation combined with two methods, the effects of removing COD_{Mn} and turbidity is better than alone one of the methods used.
- In speed of the water clear, microbubble coagulation floatation is faster than pure microbubble flotation and coagulation deposition.
- The better design of water treatment equipment should consider the results of experiments.

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