

Research on the Settlement Performance of Flocculants on the Sediment of Mine River

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Abstract. In view of adding different flocculant to the mine river sediment, the influence of different flocculants on the sedimentation performance of the mine river sediment was investigated. The experimental results show that the selected flocculant, cationic polyacrylamide (CPAM), has an evident effect on the flocculation and settlement of the mine river sediment. The final flocculation effect was enhanced with faster settling speed. The flocculation effect was optimized when 10 mL CPAM flocculant (0.2wt%) was added, followed by 3 minutes of stirring. The dewatering effect of the flocculated sediment can be enhanced with decreased solid content of the sediment.

1 Introduction

During the process of mining, acid wastewater containing a large number of organic pollutants and heavy metal ions is released due to the discharge of mining wastewater and beneficiation waste liquid, as well as the accumulation and leaching of solid wastes such as mining waste rock and tailings[1]. The wastewater, in the form of point source and non-point source pollution, are collected into the receiving water body around the mining area and further transferred and transformed through a series of physical, chemical, and biological processes. Most of the pollutants are transferred from the liquid phase to the solid phase and finally combined with the sediments to form the unique mine river sediment[2]. The pollutants in sediment mainly include organic pollutants and heavy metals. When natural conditions change or human factors interfere, it is easy to cause endogenous pollution. Pollutants in the sediment will be re-released into the water, consuming dissolved oxygen in water, resulting in water quality deterioration and odor diffusion. Additionally, heavy metal pollution in sediment can easily cause damage to human health, animals and plants through the enrichment of the food chain[3,4].

Dredging is an important method to remediate river water pollution. However, the amount of sediment after dredging is large, and its water content and pathogenic microorganism content are high. In order to prevent the accumulation of dredged sediments from causing potential adverse effects on the environment, it is necessary to reduce amount and remove most of the water[5,6]. Now the technical method commonly used in sediment

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dewatering is “dewatering conditioner + mechanical dewatering”. Adding flocculants to the sediment for conditioning, improving the void structure in the mud, adding filtration channels, and finally dewatering by mechanical means, this is an effective technology for rapid reduction and resource utilization of river sediment [7]

At present, the most widely used flocculants can be divided into two categories: inorganic flocculants and organic flocculants. Inorganic flocculants can be divided into low-molecular flocculants and high-molecular flocculants according to their molecular weight. Low-molecular flocculants have been basically replaced by high-molecular flocculants because of their large usage, large residues, and poor effect of dehydration. At present, the commonly used polymer flocculants mainly include aluminum salt and iron salt. Turchiuli studied the effect of floc structure produced by iron-aluminum flocculant on sludge dewatering performance[8]. The research results show that under the same control conditions, the floc structure produced by iron salts can produce more free water, and the combined water content is lower, and the degree of sludge dehydration is higher. Compared with inorganic polymer flocculants, organic polymer flocculants has advantages of many types, good use effect and the like. At the same time, the effect can be improved with larger flocs production and faster settling speed. Additionally, less pollution of the flocculated sludge can expand their scope of applications. Fan et al. used chemical destabilization and solid-liquid separation methods to study bentonite mud in the construction of Beijing-Shanghai high-speed railway. The results show that anionic polyacrylamide has the best effect on bentonite mud destabilization and solid-liquid separation[9].

With the improvement of national environmental protection requirements, higher requirements have been raised for the dewatering treatment of polluted river sediment[10]. Based on this, research on flocculation and dewatering of sediments in mine rivers with different flocculants is essential. Exploring suitable flocculants, improving the efficiency of dewatering of sediments, reducing the dewatering time, and providing a reference for the reduction treatment of sediments in mines rivers were investigated in this study.

2 Materials and methods

2.1 materials and reagents

The sediment was taken from a river polluted by mine wastewater in a county in Anhui Province, China. After retrieval, it was stored in a refrigerator at 4 °C for later use. The basic characteristic parameters of the sediment are shown in Table 1.

Table 1. Basic characteristic parameters of sediment

Indicator	pH	Density	Moisture content	Solid content	Organic content
Sediment	4.6	1.11 g/m ³	66.3%	33.4%	15.1%

Polyaluminum chloride (PAC, AR), 10% solution was prepared in the experiment); cationic polyacrylamide (CPAM, AR) 0.2% solution was prepared in the experiment; anionic poly Acrylamide (APAM, AR) 0.2% solution was prepared in the experiment.

2.2 Equipments and Instruments

The instruments and equipment used in the experiment are constant temperature oven, balance, pH meter, convenient scale for laboratory use, muffle stove, etc.

2.3 Methods

2.3.1 Screening of flocculant

The initial sediment was put into a measuring cylinder of 100 mL, and the same amount of different kinds of flocculants were added for conditioning. After slowly stirring, the flocculants with better settling effect were selected for testing.

2.3.2 Single factor experiment

(1) Influence of the amount of flocculant on the sedimentation effect

Five parts of prepared 100mL sediment were placed into a 100mL measuring cylinder. 0mL, 0.5 mL, 2.5 mL, 5 mL and 10 mL of flocculant were added respectively. After slowly stirring, the flocculant stood for 30 min. The percentage of sediment precipitation volume at 1 min, 5 min, 15 min and 30 min was recorded and calculated.

(2) Influence of stirring time on sedimentation effect

Take 6 parts of 100 mL sediment prepared and place them in a measuring cylinder. The same amount of flocculant was added and stirred slowly and uniformly for 0min, 1 min, 2 min, 3 min, 4 min and 5 min, respectively, and then stood for 30min. The percentage of sediment precipitation volume at 5 min, 10 min, 20 min and 30min was recorded and calculated.

2.3.3 Pressure filtration

(1) Take 4 parts of the prepared sediment with the same quality, add the same amount of flocculant, stir it evenly and inject it into the bag. Under the same stress area (0.09m^2), apply different pressures of 0 N, 145 N, 243 N and 340 N, record the weight of the sediment in different time periods and calculate the solid content.

(2) Take 4 parts of sediment and prepare sediment samples with solid content of 5%, 10%, 15%, 20%, add the same amount of flocculant, stir evenly, pour into the bag, and apply the same pressure, Record the weight of mud in different time periods.

2.4 Method for evaluation of dehydration performance

(1) Sediment settlement performance index

Sediment settling performance is expressed by sludge settling volume percentage (SV). It refers to the percentage of the initial volume of the sedimentation sludge formed after adding the flocculant and mixing uniformly. The smaller the SV, the better the sedimentation performance of the sediment.

(2) Evaluation index of dewatering degree of sediment

The solid content of the sediment after pressure filtration was taken as the evaluation standard of the dewatering performance of the sediment after conditioning. The solid content was measured by weight method: the sediment was pumped into the bag after conditioning to apply pressure, and weighed in different time periods. The calculation formula of solid content is as follows:

$$Q_i = \frac{m_0(1-q)}{m_i} \times 100\% \quad (1)$$

Where, Q_i is solid content (%), m_0 is the initial weight of sediment (kg), m_i is the weight of sediment at time i (kg), q is the initial moisture content (%) of the bottom sediment.

3 Results and discussion

3.1 Change of coagulant on sedimentation performance of sediment

Different flocculants were added to the sediment, and after stirring and standing for 30 min, the apparent state of sediment settlement was shown in Table 2.

Table 2. The apparent phenomena of different flocculants on the flocculation of sediment

Flocculant	Flocculation effect	Clarification of supernatant
PAC	Has flocculating effect	Muddy
CPAM	The effect is good	Clarify
APAM	Floc scattered	More clarification
Calcium oxide	No effect	More clarification
Citric acid	No effect	No effect
Chitosan	No effect	No effect
Cellulose	No effect	No effect

It can be seen that organic polymer flocculants such as PAC, CPAM and APAM have obvious flocculation effect on the sediment, while calcium oxide and citric acid have no obvious flocculation effect on the sediment. The effect of chitosan and cellulose on the flocculation of sediment is not ideal. Chitosan, as a kind of polysaccharide natural polymer flocculant, has flocculation effect because it contains a large number of free amino groups and can show the properties of cationic polyelectrolyte under appropriate conditions[11]. However, in this experiment, chitosan has no obvious flocculation effect on the sediment. Studies have shown that chitosan is suitable for alkaline environment, and the sediment used in the experiment is highly acidic, which restricts the flocculation effect. Cellulose is a polysaccharide composed of many glucose molecules connected by β -1, 4-glycosidized bond. It has a high molecular weight, high viscosity, and its molecular chain winding is not easy to expand, which will weaken its flocculation effect[12]. The final flocculation effects of different flocculants on river sediment were compared, and CPAM with better flocculant was selected as the flocculant for further tests.

3.2 Single factor experiment

(1) Influence of the amount of flocculant on the flocculation effect of sediment

Fig.1. shows the flocculation effect of CPAM on sediment. The experimental results show that with increase amount of flocculant, the flocculation effect is more obvious, the

sedimentation speed is faster, the flocculant is compact, and the final sedimentation effect is better. CPAM is a commonly used organic synthetic polymer flocculant. Its polar groups can adsorb suspended particles in water, and through bridging or electric neutralization, flocculent with a larger volume can be formed between small particles to promote sedimentation[13]. In this experiment, the optimal dosage of 0.2% CPAM was 10 mL.

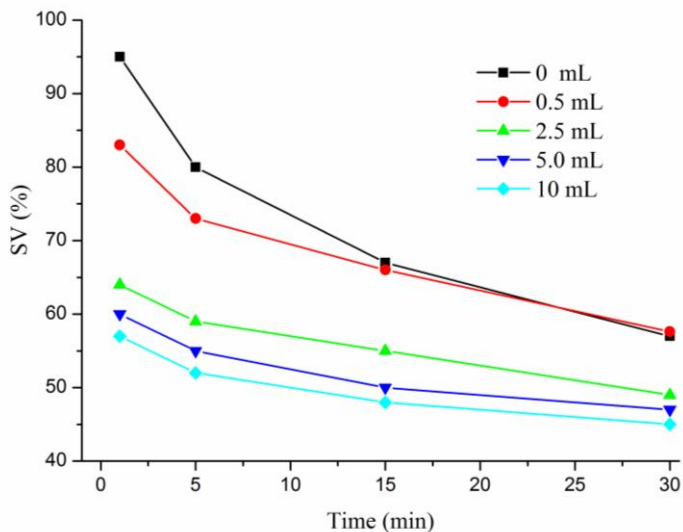


Fig.1. The influence of the dosage of flocculant on the flocculation effect of sediment

(2)The influence of different stirring time on the settling effect

Fig.2. shows the influence of different stirring time on the flocculation of sediment. The results show that different stirring time has an obvious effect on the flocculation of sediment. When the stirring time is 3 min, the flocculation effect is the best. Within a certain range, the longer the stirring time, the better the effect, but with the extension of stirring time, the effect gradually deteriorated. The possible reason is that CPAM is a polymer flocculant with high molecular weight and long chain. Through bridging, smaller particles are connected to larger particles realizing particle sedimentation. In a certain range, the particles can be captured more easily with longer stirring time, and the more easily the particles are captured. However, if the stirring time is too long, the condensed large particles will be broken, thus reducing the flocculation effect.

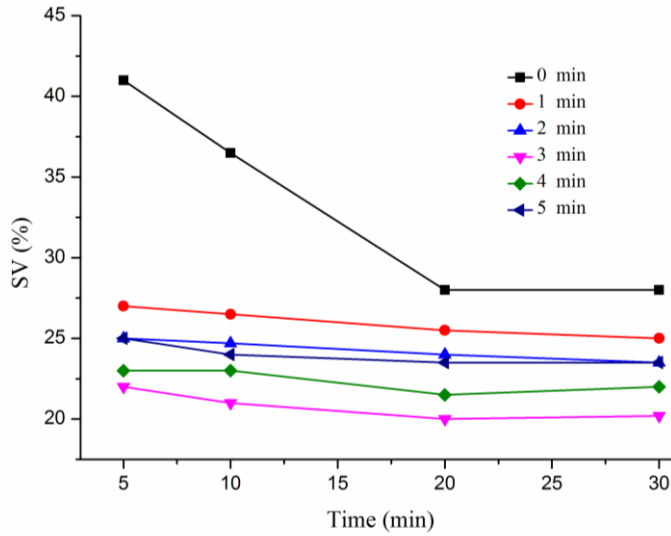


Fig.2. The effect of mixing time on the flocculation effect of bottom sludge

3.3 Pressure filtration experiment

Fig.3. shows the variation curve of sludge dewatering effect with time after applying different pressures under the flocculation action of CPAM. It can be seen that the solid content of the sediment increased gradually with the extension of time. After 7 days of dehydration, the solid content of the sediment reached more than 90%, which was slightly higher than the dehydration test without pressure. With the increase of applied pressure, the solid content also increases slightly.

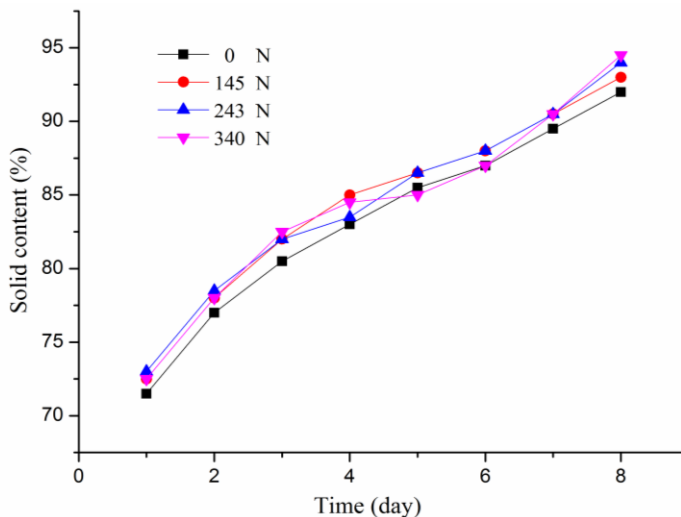


Fig.3. Study on the effect of sludge dewatering under different pressures

Fig.4. shows the study on the flocculation and dehydration effect of sediment with different solid content. It can be seen that under the flocculation action of CPAM, the

dewatering effect of sediment with different solid content is more obvious with the extension of time after the same pressure is applied. The lower the solid content, the more obvious the dewatering effect.

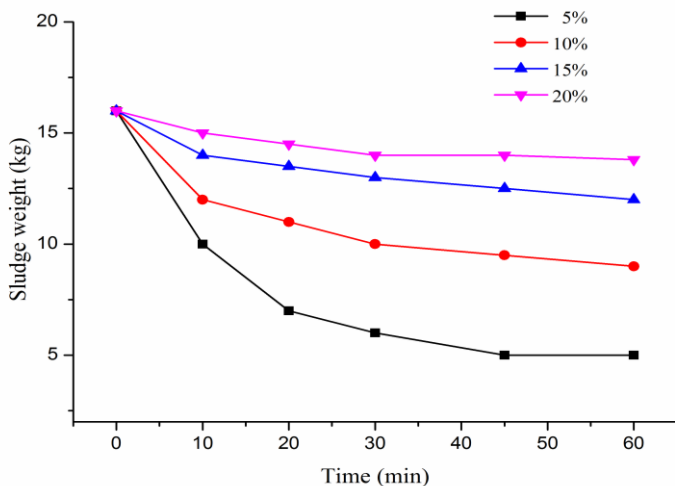


Fig. 4. Research on the dewatering effect of sediments with different solid content

4 Conclusions

(1) Among the flocculants used in the test, CPAM has a remarkable flocculation effect on the sediment of the mine river. The final flocculation effect can be optimized maximumly with certain sedimentation rate, compact floc and clarification of supernatant.

(2) Both the dosage and stirring time had significant effects on the flocculation of sediment. When the dosage of 0.2% CPAM was 10 mL and the stirring time was 3min, the effect was better.

(3) Pressure has an effect on sediment dehydration, and the solid content increases with the increase of pressure, but the increase is not obvious. It should be noted that the flocculation dehydration can be achieved effectively with lower solid content of mine river

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