

Study on improvement of sludge dewaterability with H₂O₂ cell lysis

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Abstract. Excess sludge is the product of sewage treatment plants. With continuous perfection of municipal sewage treatment facilities in China, sludge output increases as a result of the growth of sewage treatment plants. Excess sludge has complicated compositions, including heavy metals, PPCPs, persistent organic pollutants. It owns high contents of organic matters and water. High-efficiency and low-cost dehydration of sludge is the key of sludge disposal. How to improve sludge dehydration efficiency is the research hotspot in the world. In this study, effects of hydrogen peroxide content and pH on sludge dehydration were discussed by chemical disintegration technique. The optimal hydrogen peroxide content and pH were discussed, aiming to search a high-efficiency sludge conditioner.

1. Introduction

With urbanization progress in China, environmental protection awareness of ordinary people enhances gradually and the treatment scale of urban domestic sewage expands continuously, thus resulting in sharp increase of excess sludge. Excess sludge is a kind of flocculent granules with extremely high moisture content. Extracellular polymeric substances (EPS) outside sludge bacteria are an important cause of water gathering. Besides, it contains suspended solids, microorganism, organic matters, N, P and K, heavy metals, pathogenic microorganism, organic pollutants, etc. Improper disposal of excess sludge will cause serious pollution to surrounding ecological environment ^[1]. At present, about 44% excess sludge in China are treated by agricultural utilization method, about 31% are treated by sanitary land fill, 11% are treated by other methods, and about 14% are disposed directly without any treatment ^[2]. Sludge dehydration is the key of sewage treatment. Many studies have been reported to overcome it. Most sewage treatment plants in China use polyaluminium chloride (PAC), polyferric sulfate (PAFC) and polyacrylamide ^[3] as conditioners to improve sludge dehydration. However, these conditioners will influence follow-up resource utilization of sludge, such as compost, electricity generation, and utilization as nutrient soil. Sludge oxidization by hydroxyl radicals which are produced by physical and chemical systems like ozone, ultrasonic wave, hydrogen peroxide^[4] and electrochemistry^[5] is another sludge dehydration method. Hydrogen peroxide is characteristics of convenient addition, high oxidation efficiency and good dehydration conditioning effect. It is used as the conditioner in this paper. Effects of hydrogen peroxide content and pH on sludge dehydration were discussed, aiming to



find an efficient environment-friendly conditioner. This is conducive for resource utilization after sludge dehydration. Research results provide technical supports for sludge dehydration and resource recycle engineering.

2. Experimental

2.1. Instrument and equipment

Analytical balance and circulating water-type vacuum pump.

2.2. Research method

The fresh sludge was taken from secondary sedimentation tank in Xintang wastewater treatment plant, and stoaged in the 4 °C refrigerator. 1 L muddy water was placed in the beaker, and some of H₂O₂ was added into beaker. Diluted acid was used to adjust the pH of solution. The conditioned sludge was poured into Buchner funnel for vacuum filtration, until no water flew out of Buchner funnel within 1min. Then water content of the sludge cake was determined by analytical balance.

3. Results and Discuss

3.1. Effect of hydrogen peroxide content

Since hydrogen peroxide has stronger stability and oxidability under acid conditions than under neural and alkaline conditions, initial pH of sludge was adjusted to 3 by 1mol/L dilute sulphuric acid before studying effects of hydrogen peroxide content on sludge dehydration. Conditioning temperature and time were set 25 °C and 1 h. According to the principle of single-factor variable, effects of hydrogen peroxide contents (0 mL/L, 0.5 mL/L, 1.0 mL/L, 1.5 mL/L, 2.0 mL/L, 2.5 mL/L, 3.0 mL/L, 4.0 mL/L and 5.0mL/L) on moisture content and floating volume of dehydrated sludge cake were analyzed. Test results are shown in Figure 1.

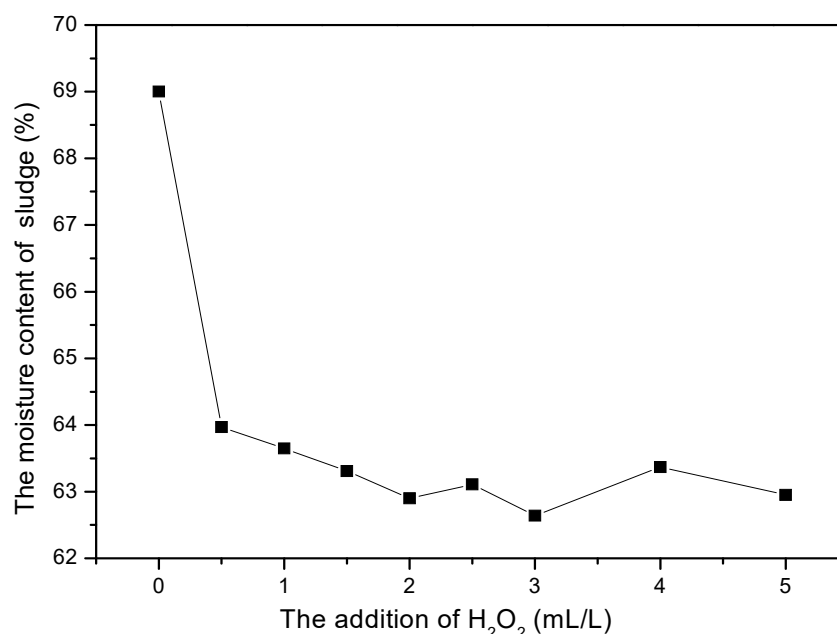


Figure 1. The effect of H₂O₂ on the moisture content of dehydrated sludge cake (the original pH was adjusted to 3)

The moisture content of dehydrated sludge cake is 69% when the hydrogen peroxide content is 0 mL/L. Under low hydrogen peroxide content, moisture content declines quickly and decreases by 6.10% to 62.90% when hydrogen peroxide content 2 mL/L, indicating that sludge dehydration is improved significantly. At this moment, moisture content is close to the minimum and changes slightly after continuous increase of hydrogen peroxide content. The moisture content reaches the minimum (62.64%) when hydrogen peroxide content is 3 mL/L, which is only 0.26% lower than that under 2 mL/L. Later, moisture content remains basically same with the continuous growth of hydrogen peroxide content. Therefore, the optimal hydrogen peroxide content is determined 2 mL/L preliminarily, which can improve sludge dehydration effectively. Moisture content of the dehydrated sludge cake drop significantly after hydrogen peroxide is added. This has two reasons. Due to strong oxidization of hydrogen peroxide under acid conditions, sludge can be dissolved effectively. This will release constitution water in sludge bacterial cells, increase free water in sludge and intensify sludge dehydration, manifested by sharp reduction of moisture content of the cake. On the other hand, EPS in sludge can be degraded effectively because of strong oxidability of hydroxyl radicals, so the sludge structure is loosened and water in EPS is released, resulting in reduction of moisture content. However, moisture content increases with the continuous growth of hydrogen peroxide content, which might be caused by over oxidation of sludge under excessive hydrogen peroxide content.

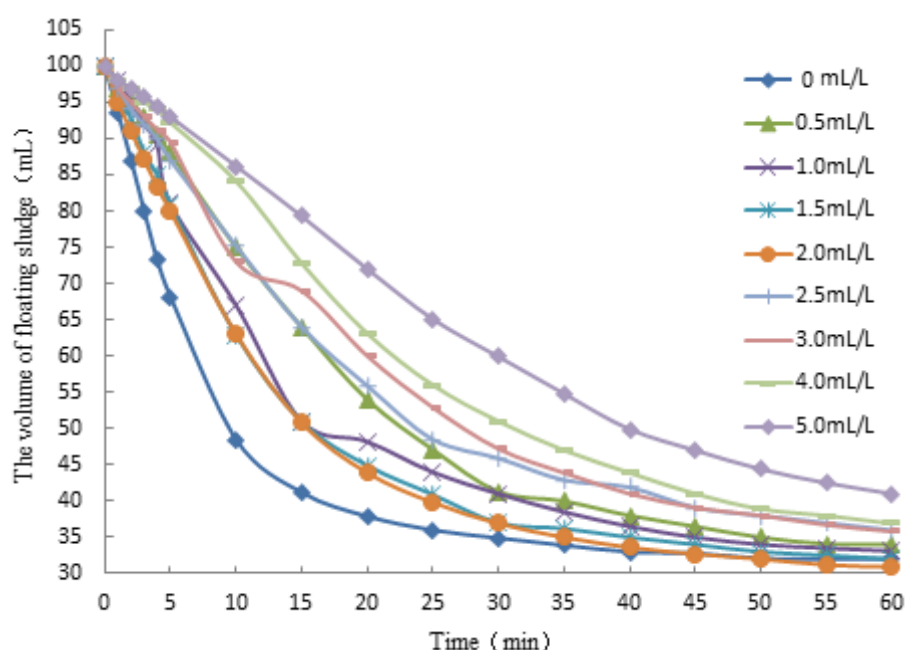


Figure 2. The effect of H_2O_2 addition on the volume of floating sludge

During sludge conditioning by hydrogen peroxide, microorganism cells which adhered on sludge surface are disintegrated and EPS is degraded due to lysis. Moreover, hydrogen peroxide will produce gases like CO_2 when oxidizing organic matters and self-oxidization of hydrogen peroxide will generate O_2 . These gases will carry sludge particles floating, showing obvious solid-liquid layering in sludge. The upper layer is sludge solids and the lower layer is clear liquor. In actual sludge treatment, air flotation thickening is an effective sludge thickening method.

To sum up, sludge dehydration is closely related with hydrogen peroxide content. With comprehensive considerations to dehydration degree, dehydration speed, improvement of air floating performances (Figure 2) and economical efficiency of actual operation, the optimal hydrogen peroxide content was set 2 mL/L.

3.2. Experiment without adjusting pH

This experiment was carried out by using the original sludge sample (pH=8). Experimental steps are same with those in Section 3.1 and the experiment in Section 3.1 is the control group at pH 3. Results are shown in Figure 3. Under weak alkaline conditions, the floating performance of sludge is unsatisfactory. When hydrogen peroxide content is 4 mL/L, the floating volume of sludge is 46 mL after putting static for 60 min, which is higher than that under acid conditions. Therefore, non-adjustment of pH is disadvantageous for sludge-water separation.

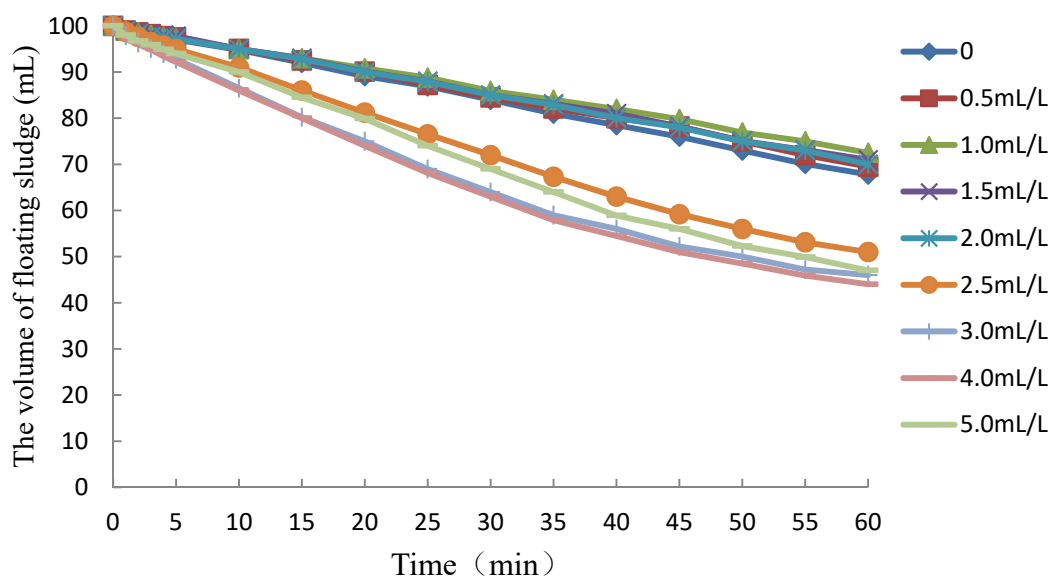


Figure 3. The effect of H₂O₂ addition on the volume of floating sludge (unadjusted pH)

4. Conclusion

Moisture content in sludge cake is 62.90 % when the initial pH is 3 and hydrogen peroxide content is 2 mL/L, which is 6.10% lower than that of the blank sample. Moisture content in sludge cake decreases slightly when hydrogen peroxide content increases from 2 mL/L to 3 mL/L. However, sludge dehydration worsens with the continuous increase of hydrogen peroxide content. When the initial pH is not adjusted, there's large floating volume of sludge, which is against sludge-water separation. Therefore, the optimal conditions for sludge disintegration are pH3 and 2 mL/L of hydrogen peroxide content.

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