Influences of Different Conditioners on Dehydration Ratio of Activated Sludge

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Abstract. Excess sludge contains a large quantity of water with water content reaching about 97%-99%. Besides microorganisms and germs, the sludge is of complicated composition, including heavy metals, persistent organic pollutants, PPCPs, endocrine disrupters, etc. It covers a large area with harmfulness, so it needs further treatment. However, due to existence of extracellular polymeric substances in the sludge, the sludge has poor dehydration property, so how to improve dehydration of sludge is a difficult point in water treatment industry. Chemical conditioning—mechanical dehydration method is sludge dehydration technology which has been widely applied in China. Most sludge treatment plants use organic and inorganic conditioners like polyacrylamide (PAM), polyaluminum chloride (PAC) and polymerized ferrous sulfate (PFS), etc. With characteristics of low toxicity and degradation resistance, these conditioners pose potential risks to the environment and they are adverse to follow-up resource utilization. Therefore, influences of 17 conditioners on sludge dehydration ratio were discussed in this paper, expecting to seek for green, environmentally friendly and highly efficient conditioner so as to improve resource utilization ratio of sludge.

1.Introduction
The sludge in sludge treatment has high hydrophilia[1], if the sludge is directly put under mechanical dehydration, sludge water content will still reach as high as 80% or so, but landfill standard of solid waste in China is that water content should be less than 60%. Hence, it’s necessary to adopt effective conditioning method to pre-treat the sludge so as to change physiochemical properties and components on surfaces of sludge particles, damage some colloid structures of sludge particles, reduce its affinity with water and then improve sludge dehydration property. Common conditioning methods are physical conditioning method, chemical conditioning method[2] and physicochemical integrated conditioning method. Among chemical conditioning methods, commonly used conditioners are generally divided into three major types—inorganic, organic and compound conditioners.

With activated sludge in Xintang sewage treatment plant in Guangzhou taken as research object, chemical conditioning method will be used in this research to make experimental determination of water contents of filter cakes after being conditioned and vacuum filtration. Through comparison of improving effects of different conditioners on sludge dehydration properties, it’s hoped to seek for a green and low-cost conditioner so as to realize resource utilization of the sludge after dehydration and provide research basis for theoretical research and engineering application.
2. Experimental

2.1. Instrument and equipment
Analytical balance and circulating water-type vacuum pump.

2.2. Research method
1L water-containing sludge was placed in 1L beaker, conditioners of were added at different dosages, the conditioned sludge was transferred into Buchner funnel for pumping filtration, and then water content of the sludge cake was determined. Filter paper was placed in Buchner funnel and wetted by water, vacuum filtration was conducted until the filter paper clung to the funnel, the sludge was poured into funnel for (time) standing, and then vacuum filtration was implemented until no fluid flew out of Buchner funnel within 1min.

Figure 1. Xintang sewage treatment plant sludge conditioning and dewatering experiments. (a) conditioned sludge samples; (b) vacuum suction filter device.

3. Experimental
According to water content of sludge cake after conditioning, 17 conditioners were divided into 3 groups by their dehydration effects for discussion and analyze, namely group 1 (favorable effect): dehydration ratios were within 65~67%; group 2 (ordinary effect): dehydration ratios were within 67~69%; group 3 (poor effect): water content > 70%.

In group 1, sludge dehydration ratio by activated carbon powder was the highest being 65.66%, followed by hydrogen peroxide. Hydrogen peroxide can be decomposed into hydroxyl radicals, which have strong oxidizing property and can oxidize and damage cell walls of the sludge so as to boost lysis effect, make exudation of cell water and improve sludge dehydration ratio. Eskicioglu et al [3] found in experiment that addition of 1g/g (H₂O₂/dry sludge) in excess sludge could elevate dissolubility of sludge by 11%~34%. A company in Denmark used hydrogen peroxide-oxidizing lysis technology, and the sludge could be directly used in agricultural production through acidification, oxidation and flocculant precipitation. After H₂O₂ was added under acid condition, most microorganisms could be extinguished and degraded, sludge volume could be reduced by 25%~50%, and sludge
biodegradability turned good [4].

Table 1. The effects of seventeen conditioner on the sludge dehydration

| Group | Conditioner | Moisture content(%) |
|-------|-------------|---------------------|
| 1     | 100% activated carbon powder(1:1) | 65.66 |
|       | 5%H2O2 (50 ml) | 66.78 |
|       | 5%PAM | 67.11 |
|       | 0.3%PAM | 68.01 |
|       | 100% biomass powder | 67.56 |
|       | 7%FeCl3+15%CaO+0.15PAM | 67.26 |
|       | 3%FeCl3+3%CaO+0.1%PAM | 67.73 |
| 2     | 3 ml H2O2+3%FeCl3+3%CaO+10% biomass powder | 67.34 |
|       | 3%FeCl3+3%CaO+10% biomass powder | 67.45 |
|       | 0.1%PAM+3%FeCl3+3%CaO+10% biomass powder | 67.83 |
|       | 20%FeCl3 | 67.79 |
|       | 3%FeCl3+3%CaO | 68.03 |
|       | 3%FeCl3+50% biomass powder | 68.34 |
| 3     | 0.1%PAM+3mLH2O2+3%FeCl3+3%CaO+10% biomass powder+0.1%PAM | 71.09 |
|       | no conditioner | 72.01 |
|       | 20%NaOH | 73.33 |
|       | 20%CaO | 74.29 |

Notes: conditioner proportion takes dry sludge substances as the standard and is calculated by dry sludge substances 2g/L (water content 0.02%).

In group 2, when 100% biomass powders were added, sludge dehydration ratio was 67.56%. Biomass powders were added in the sludge as filter aid, and their influence on dehydration property of flocculent sludge. Dehydration test results indicated that biomass powders could accelerate dehydration. As compressibility and permeability[5] of sludge are important influence factors on improving sludge dehydration property and obtaining higher solid content, dehydration ratio can be elevated by reducing compressibility and enhancing permeability. Biomass powders can form bridging between sludge flocs to maintain permeability of sludge cake and promote water drainage. Besides they can help to form porous and permeable crystalline structure which holds solid particles and allows moisture to pass through, so biomass powders can obviously condition dehydration property of flocculent sludge. Mixture of sludge and biomass powders can not only increase heat value but also can improve sludge dehydration property. Addition of biomass powders contributes to preparing sludge into biomass particular fuels for incineration and electricity generation, etc. With broad sources of raw materials, chemical conditioners have low cost and dehydrated sludge can be further used to produce fertilizers, biomass fuels, etc. Increasing utilization ways can realize win-win pattern between environmental benefit and economic benefit. Combination of multiple conditioners could improve sludge dehydration to a certain degree, basically being within 67~69%. Compared with biomass powders, chemical conditioners FeCl3, PAM and CaO are adverse to follow-up resource utilization like compost, incineration and electricity generation, etc.
In group 3, sludge dehydration ratio after direct press-filtering without addition of any conditioner was 72.01%. When 20%NaOH and 20%CaO were added, dehydration ratio increased on the contrary, possibly because NaOH and CaO were of hygroscopicity.

4. Conclusion
Influences of biomass powders, hydrogen peroxide, single chemical conditioners and mixture of multiple conditioners on sludge dehydration effect were discussed. Experimental results showed that among 17 single conditioners or conditioner combinations, activated carbon has the highest dehydration efficiency on the sludge and dehydration ratio reached 65.66%. Biomass powder was green and environmentally friendly conditioner, dehydration ratio reached 67.56%, which contributed to follow-up resource utilization like being fuel rod or being used for combustion and electricity generation. For 7%FeCl$_3$+15%CaO+0.15PAM combined conditioner, it had higher dehydration ratio than single conditioners. Using effect of compound conditioner was superior to single conditioners, because flocculating agent had electrostatic adsorption, coagulant had adsorption bridging effect, and filter aid didn’t generate coagulation, but it could be skeleton builder to provide water transfer channel, and the three could interact with each other and supplement each other.

Acknowledgement
This study was supported by Special applied project in guangdong province, China (No.2015B020235004) and Guangdong Natural Science Foundation (No. 2014A030313761).

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