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Effect of adding alum sludge from water treatment plant on sewage sludge dewatering

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ABSTRACT

Alum sludge from water treatment plant contained residual polyaluminum chloride (PACl) and large amount inorganic matters. Alum sludge acted as chemical conditioner and physical conditioner improved the sewage sludge dewatering. It indicated that the addition of alum sludge reduced the dosage of polyacrylamide (PAM) and decreased the moisture content of sewage sludge. The moisture content was 64% when the blend ratio was 1 kg/kg (dry alum sludge/dry sewage sludge) with plate-and-frame filter press. The 3D-excitation–emission matrix (3D-EEM) was used to analyze the sludge dewatering process. A mechanism hypothesis of adding alum sludge in sewage sludge for improving the sludge dewatering was proposed. Alum sludge implements the charge neutralization and adsorption bridging effect, provides friction and squeeze for crushing sludge particles even cell, and acts as skeleton builders in the sludge to improve the sludge dewatering.

Introduction

Over the last decade the increase in municipal wastewater treatment activities has been confronted with a dramatic increase of sewage sludge amount [1]. The sludge commonly contains over 90% water. The volume of the sludge must be reduced before disposal for low costs of transportation and handling [2]. However, sewage sludge is difficult to dewater [3].

Chemical conditioning prior to mechanical dewatering is usually used. It is well known that the mechanism of chemical conditioning is to destroy the colloidal frame of sludge, and flocculate the sludge flocs by added conditioners, such as calcium oxide, ferric chloride, polyacrylamide, etc. [4–6].

However, chemical conditioning has difficulties improving the sludge cake solids content because sewage sludge dewatering is often hindered by blinding of the filtration media and the filter cake itself [7]. Thus, physical conditioners, which are often known as skeleton builders or filter aids, are commonly used to improve the sludge permeability and mechanical strength, and reduce the sludge compressibility [2]. The most used physical conditioners are fly ash [8–10], gypsum [11–13] and lime [14,15], bagasse [16], coal [17], lignite [7], humus soil [18], wood chips [19], wheat dregs [20], synthetic fibers [21], red mud [22] and struvite [23]. Especially, alum sludge is also used as physical conditioner [24]. These physical conditioners can form a permeable and more rigid lattice structure to maintain porosity at high pressures during the mechanical dewatering [2].

Alum sludge is the waste product of water treatment plant in which aluminum salts, either alum orPACl are commonly used. Large quantities of alum sludge are produced, which may cause serious environmental problems if it is not appropriately disposed [24,25]. Alum sludge contains a lot of residual aluminum hydroxide and inorganic granular matters [26]. Adding alum sludge to improve the sewage sludge dewaterability was proposed because residual aluminum hydroxide acts as chemical conditioner and inorganic granular matters act as physical conditioners [27–29].

The presence of aluminum hydroxide enhances settling velocity and dewaterability of biological sludge [27]. It indicates the polymer dose required for dewatering the blended sludge is reduced, compared with the sewage sludge alone. Alum sludge acts as skeleton builder and renders the blended sludge more incompressible which is beneficial for sludge dewatering [28]. The alum sludge of drinking water treatment as the recycle sludge contained residual PACl or PAM, which was beneficial to improve sludge dewaterability. So, auditing alum sludge can reduce the dosage of polymer and decrease the cost. Simultaneously, it also decreased risk for using polymer as PACl or PAM in following waste sludge treatment.

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However, a few studies have investigated the blending of alum sludge and sewage sludge dewaterability. The objective of this work was to study the effect of alum sludge on the specific resistance to filtration (SRF), the moisture content by plate-and-frame filter press, the mechanism of dewatering.

Materials and methods

Materials

The sewage sludge was gathered from the secondary sedimentation tank at a municipal wastewater treatment plant. The moisture content of the raw sludge was approximately 98%. The pH values were at 6.5–7.1 and the VSS/SS was about 75%. The sewage sludge had adhesion and the color was yellowish-brown. All experiments were completed in a day after sampling in order to minimize changes in sludge characteristics due to microbial activity. The sludge was stored at room temperature.

The alum sludge was the mixture of sedimentation tank sludge and backwash water sludge from filter in a water treatment plant which used PACl as the primary coagulant, and then dewatered the mixture sludge by machinery after adding the polyacrylamide (PAM), its moisture content was about 63%. In drinking water treatment plant, PACl and PAM dosed to the alum sludge are based on water, the dosage of PACl and PAM was 27 g/t water and 0.21 g/t water (the values of PACl and PAM are specific values in the drinking water treatment plant in the study). In addition, the original process of drinking water treatment is composed of coagulation, sedimentation, filtration, disinfection. Alum sludge contains a lot of residual aluminum hydroxide. The organic matters of alum sludge mainly contain humic-like matters.

Plate-and-frame filter press sludge dewatering process

Plate and frame filter press was made up of air compressor, plate and frame, pressure pump. The pressure was 1 ± 0.05 MPa, the pressure time is 1.5 h. The plate and frame size was 15 cm × 15 cm × 1.3 cm. Warp and weft density and thickness of filter cloth were 10.6 root/cm and 15.6 root/cm and 0.9 mm, respectively (Fig. 1).

Analytical methods

Assessment of the sludge dewatering performance

The specific resistance to filtration (SRF) is a comprehensive indicator to measure the dewatering property of the sludge, generally, a high SRF value indicates poor sludge dewaterability [30]. The filtration was performed using a 90 mm diameter filter paper at an applied vacuum pressure of 1 ± 0.05 MPa. SRF was determined using a plot of filtration time/filtrate volume (t/V) vs. filtrate volume (V). SRF and moisture content were measured according to a method reported previously [31]. Additionally, the moisture content measured after filtration in the study. But the moisture content of original sludge in treatment plants measured before filtration.

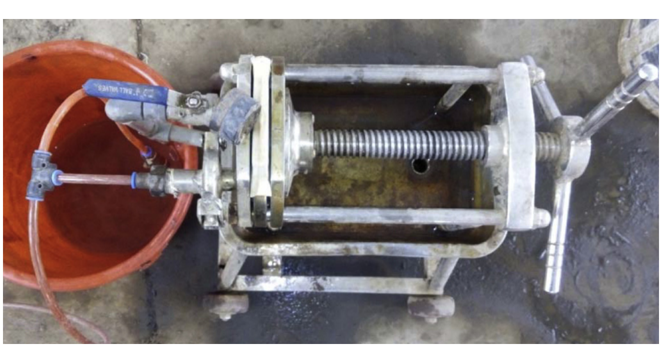

Fig. 1. The device of plate-and-frame filter experiment.

Methods for measurements and analysis

The dewatered alum sludge that dehydrated by centrifugal (moisture content 63%) was added to sewage sludge (10 L). The mixed sludge was to use the alum sludge and urban sewage treatment plant sludge with different weight ratio in experiment, and then mixed about 10 min until blended. The 1 kg/kg represented blending 1 kg dry alum sludge and 1 kg dry sewage sludge. The sludge samples were dewatered by plate and frame filter press about 1.5 h with 1 ± 0.05 MPa.

The sludge samples were tested on a field emission scanning electron microscope (SEM) (Zeiss Sigma, GER). The SEM sample preparations and analysis were performed as the manual operation instruction.

The particle sizes of the conditioned sludge flocs and sewage sludge were determined by Mini laser particle size analyzer (Microtrac S3500, USA), which enables the measurement in the range of 0.05–900 μm.

The main components of the sludge samples were measured using energy dispersive spectrometry (EDS) with an accelerating voltage of 20 kV to visualize the element components.

The 3D-EEM of supernatant and press-filtrate of sewage sludge and blended sludge (the blend ratios was 1 kg/kg) were conducted by using a F97 luminescence spectrophotometer (Shanghai Lengguang Technology Co. Ltd). PTM voltage was 500 V, the excitation interval was 10 nm and the emission interval was 1 nm. Both of the excitation and emission wavelengths were varied between 200 and 600 nm and the scan speed was set at 6000 nm/min. Analysis of 3D-EEM data was achieved by origin 8.5.

Results and discussion

Effect of adding alum sludge and PAM dose on SRF of sewage sludge

The dewatering behavior as measured by SRF of the original sewage sludge and blended sludge at two blend ratios (0 and 1 kg/kg) as a function of PAM dose are shown in Fig. 2. The SRF of

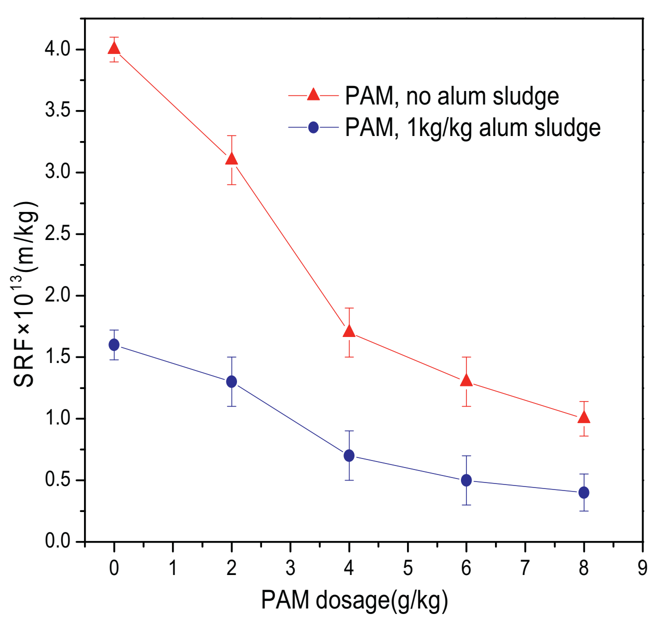

Fig. 2. The change of sludge SRF with different dosage of PAM.