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IMPACT OF SLUDGE CONDITIONING ON MECHANICAL DEWATERING AND CONVECTIVE DRYING

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Abstract: Management of sludge produced within wastewater treatment plants has become a key issue. After thickening, the removal of remaining water using mechanical dewatering and/or thermal drying is essential before any type of valorization. Polymers are usually employed in the conditioning step in order to promote particle aggregation, making the dewatering easier. In this work the impact of the polymer dosage and nature on dewatering and convective drying of sludge is studied. Results clearly show the impact of conditioning on dewatering performances, however no effect on drying has been observed within the range of tested experimental conditions.

Keywords: **sludge, flocculation, dewatering, convective drying**

INTRODUCTION

Because of stringent environmental regulations, the production of sludge from wastewater treatment plants has been continuously increasing worldwide for several years. The valorization of the growing amounts of sludge has become a key issue. When taking a look at recent legislations around the world, it appears that two major options prevail for sludge disposal: energy valorization and landspreading (Spinosa 2001).

Sludges refer to the excess of biomass, i.e. microorganisms, generated by the biological step within wastewater treatment plants (WWTP). Excess sludge is extracted from the aeration tanks and sent to thickeners in order to separate the liquid from the solid phase. After thickeners, sludges are still liquid, containing sometimes less than 1% dry solids (DS). Conditioning, mechanical and/or thermal dewatering are then realized in order to reduce their water content. Ideally, the highest possible amount of water has to have been removed at the end of mechanical dewatering in order to save energy during the drying process.

In the conditioning operation, polymers are added to the sludge in order to promote particle aggregation, hence making dewatering easier. Depending on the dewatering technique, the so-called sludge cake reaches around 20 to 25% DS. Thermal drying can then be used to remove totally or partially the remaining water, depending on sludge final use. Drying presents several advantages: it can lower the water content below 5 % DS. This obviously reduces the mass and volume of waste and, consequently, the cost for storage, handling and transport. The removal of water to such a low level increases drastically the lower calorific value, transforming the sludge into an acceptable combustible. Furthermore, the dried sludge is a pathogen free, stabilized material provided both the temperature and the residence time are sufficiently important.

Conditioning, dewatering and drying can not be seen as independent steps. Indeed, some WWTP managers have observed that, in some cases, the shear stresses underwent by the sludge in centrifuges will alter its drying behavior. Overdosage of conditioning polymer has also been referred to induce drying slowing down. Pumping or mixing is also known to have a negative impact on the drying step (Huron et al. 2010).

Many studies have been devoted to the determination of the optimum polymer dose or nature, using rheological measurements, capillary suction time, … (Lotito et al. 1990; Christensen et al. 1993; Wu et al. 2000; Saveyn et al. 2005; Saveyn et al. 2008)Recent papers focused particularly on the expression phase(Raynaud et al. 2010). Few scientific papers have considered the coupled effects between conditioning/dewatering and drying (Vaxelaire et al. 1999). This is why, in this work, the impact of the conditioning operations, i.e. polymer dosage and nature, on both mechanical dewatering and drying steps is investigated.

MATERIALS AND METHODS

Sludges have been collected after thickening in a WWTP located close to University.

Sludge samples have been conditioned using a bench scale jar-test by adding the chosen amount of flocculant, i.e. between 4 and 16 g/kg DS. Values higher than those usually encountered on industrial sites have been adopted in order to study the impact of overdosage. Four structured cationic polyacrylamides in emulsion form were provided by Clarflok (Belgium) distributor of SNF Floerger® products, among them the FLOPAM family (see Table 1). After conditioning, dewatering has been realized in a normalized filtration-expression cell (AFNOR 1979) under 5 bar of pressure. The specific resistance to filtration has been determined from the follow-up of filtrate mass with time, using the Carman-Kozeny equation.

Table 1. Description of flocculants

Name	FLOPAM EM 840 TBD	FLOPAMEM 840 MBL	FLOPAM EM 840 TRM	FLOPAM EM 445 TRM
Charge density	Very high	Very high	Very high	High
Molecular weight	Low	Fairly high	Very high	High
Notation	A	D	C	B

For convective drying experiments, the cake recovered after filtration has been extruded through a circular die of 12 mm diameter, producing cylindrical extrudates similar to those used in several industrial belt dryers. Extrudates are cut at a height of 15 mm, yielding samples with volume and mass of approximately 1.7 cm^3 and 2.5 g.

Individual extrudates have been dried in a specially designed convective microdryer described in a previous paper (Leonard et al. 2002). Results reported in this paper have been obtained with the following operating conditions: air temperature of 130 °C, at ambient humidity (absolute humidity ~ 0.005 $kgkg^{-1}$ dry air) and a superficial velocity of 2 ms^{-1}. The mass of the sample has been recorded every 5 s in order to determine the drying kinetics.

Desorption isotherms have also been determined using a dynamic vapor sorption equipment (DVS, Surface Measurement Systems Limited, UK).

RESULTS AND DISCUSSION

Impact of sludge conditioning on dewatering

For the 4 tested flocculants, Table 2 indicates that an increase of the dosage leads to the decrease of the specific resistance to filtration and consequently to a decrease of the filtration duration. For similar dosages, lower performances were obtained with flocculant A, i.e. with the one having the lowest molecular weight.

Fig. 1 shows that the siccity of the filtration cake first increases with the flocculant dosage, and then reach a plateau at values ranging roughly from 14 to 18%¨DS depending on the flocculant. As expected, lower siccities are obtained with flocculant A.

Table 2. Impact of flocculant nature and dosage on the specific resistance to filtration

Flocculant	Flocculant dosage (g kg^{-1} DS)	SRF (m/kg)
A	6.89	$1.01\ 10^{13}$
	8.45	$2.59\ 10^{12}$
	11.74	$1.12\ 10^{12}$
	16.77	$3.99\ 10^{11}$
B	6.84	$9.56\ 10^{12}$
	8.19	$1.87\ 10^{12}$
	11.71	$2.83\ 10^{11}$
	16.72	$9.87\ 10^{10}$
C	4.24	$1.93\ 10^{13}$
	7.20	$1.59\ 10^{12}$
	10.11	$1.03\ 10^{12}$
	14.49	$4.06\ 10^{11}$
D	4.23	$4.68\ 10^{13}$
	7.33	$1.08\ 10^{12}$
	10.12	$4.71\ 10^{11}$
	14.49	$2.90\ 10^{11}$

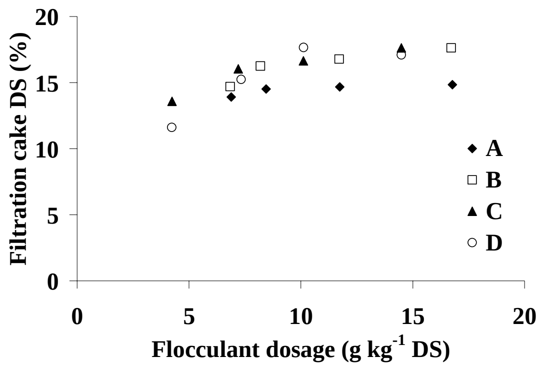

Fig. 1. Impact of flocculant dosage and nature on cake dryness

Impact of sludge conditioning on convective drying

Extrudates produced from the 16 filtration cakes were submitted to convective drying. In the range of the tested conditioning conditions, no influence could be detected on the drying curves. The determination of the desorption isotherms confirmed that the state of water inside the dewatered sludge was similar whatever the flocculant dosage or nature.

CONCLUSIONS

This preliminary work was an attempt to put in evidence the impact of the sludge conditioning on the subsequent dewatering and drying steps. Results confirm what is already well known, i.e. the impact of flocculant dosage and nature on the dewatering performances (Vaxelaire and Olivier 2006). Nevertheless, no impact could be detected on convective drying, in contrary to what has been reported within some WWTPs. Further experiments will be carried out in other to study other type of flocculants but also different types of sludges.

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