Electro-dewatering of activated sludge: filtrate flow rate analysis

Jean-Baptiste Conrardy, Jérémy Olivier, Jean Vaxelaire

Electro-dewatering of activated sludge: filtrate flow rate analysis

J.-B. Conrardy, J. Olivier, J. Vaxelaire

Laboratoire de Thermique, Energétique et Procédés, Université de Pau et des Pays de l'Adour, rue Jules Ferry, BP7511, 64075 PAU Cedex (E-mail: jean-baptiste.conrardy@univ-pau.fr)

Abstract
Dewatering of activated sludge is a difficult process. Assisting the dewatering by an electrical field improves significantly the efficiency. The purpose of this study was to analyse the kinetics of the dewatering process thanks to experiments carried out with a lab-scale pressurised electro-dewatering device. Tests were conducted under constant current density and constant voltage, respectively. Different sludge loads were considered. The kinetics of the dewatering process was monitored by calculating both, the dryness of the sludge cake and the mass flow rate of filtrate over time. It was found that only two key parameters affect significantly the mass flow rate of filtrate during the electro-dewatering process, namely the electric current intensity and the dryness of sludge cake. The dewatering kinetics of tests at constant voltage and constant current were both explained with this analysis. No influence of the sludge load was observed on the flow rate of filtrate.

Keywords. Dewatering – activated sludge – kinetics – wastewater.

INTRODUCTION
Municipal wastewater treatment leads to huge amounts of wet residues such as activated sludge. For financial reasons, the sludge needs to be dewatered prior to further disposal. Electro-kinetics effects have shown their ability to assist conventional mechanical dewatering process (Mahmoud et al., 2010; Iwata et al., 2014). The use of this combined effect is often referred as pressurized electro-osmotic dewatering (PEOD). This combined technology has been found to be cost effective compared to other drying methods (Olivier et al., 2014). Many operating parameters can influence the efficiency of such an electro-dewatering process. Since activated sludge is a biomaterial the dewatering behavior may vary due to the change of sludge characteristics over time. It may also differ from a sludge sample to another. Consequently, the comparison of the dewatering kinetics has to be operated only with a single sludge sample and with tests carried out on a rather short period of time (a week).
The purpose of the present study was to figure out how the dewatering process behaves when varying the electric current (or voltage) and the amount of sludge in the cell (sludge load), respectively.

METHODS
The experimental set-up used for this study was previously described by Mahmoud et al. (2011). It consists in a filtration/compression cell working with a pressure controlled piston moving in a cylindrical vessel (70 mm inner diameter). Two perforated disk electrodes were placed at both ends of the compression chamber. Activated sludge was directly collected from the wastewater treatment plants and flocculated with a cationic polymer prior to be thickened under gravity drainage. The dewatering kinetics was monitored by measuring the mass of filtrate over time. The dryness of the sludge cake was calculated from the cake dryness measured at the end of the process and the evolution of the mass of filtrate. Electric current and voltage were monitored as well. For all experiments the pressure was 5 bar.

RESULTS
A first series of experiments was carried out under different constant currents (200 mA, 300 mA and 400 mA) with different sludge loads (5 gDS, 10 gDS, 15 gDS). Plotting the mass flow rate of filtrate versus the sludge cake dryness turned out to be effective for explaining the dewatering kinetics of these experiments.

On figure 1, the first graph (left side) enabled to compare the flow rate of filtrate for different experiments of the first experiments series. A global decreasing trend was observed when the dryness increased (due to the dewatering process). Moreover, it appeared clearly for a given dryness that the higher the current intensity was the higher the flow rate of filtrate was. When considering two different sludge loads (5 gDS and 10 gDS), for a given current intensity, the mass flow rate of filtrate was found to be similar, at a given cake dryness, for both experiments. However it should be mentioned that this behavior led to different dewatering rate since the amount of water to be removed was different in each case. Consequently, a smaller sludge load reached faster higher dryness. At the opposite, a more important sludge load dewatered slower.

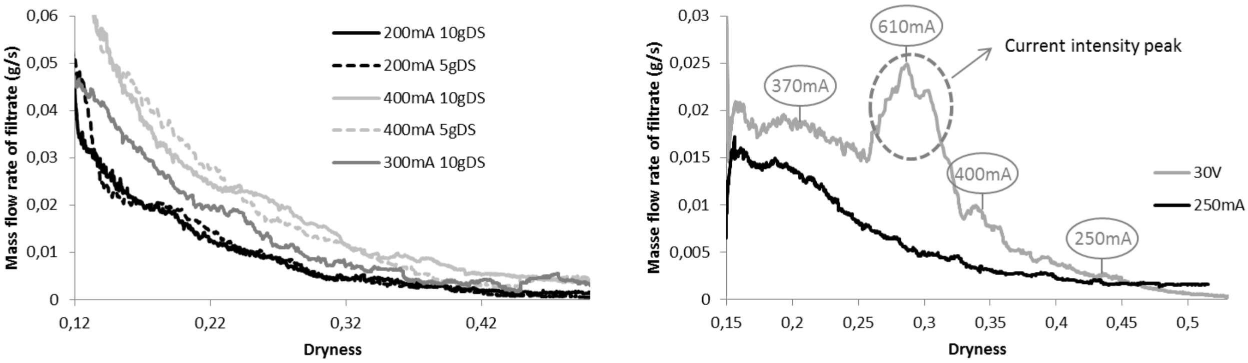

Figure 1. Influence of cake dryness, current intensity and sludge load on mass flow rate of filtrate. Tests conducted with different constant currents and sludge loads (left side). Comparison between a constant current test and a constant voltage test (right side).

A second series of experiments was carried out to compare, with a same sludge load, dewatering tests conducted under constant voltage (30 V and 40 V) and constant current (200 mA and 300 mA), respectively. During a test carried out with a constant voltage, the electric current varies over time. It starts at a moderate value, and then increases to a peak prior to decrease slowly. For this kind of test, the mass flow rate follows a similar behaviour by reaching a peak at a given dryness. The two peaks were significantly correlated for all tests carried out at constant voltage. Consequently, it is possible to assume that the flow rate was mainly correlated to the current intensity and the sludge cake dryness, respectively. Such correlations were also proposed in literature for tests conducted at constant current intensity with mineral sludge (Iwata et al., 2013).

On figure 1, the graph on the right side shows the flow rate behaviour for the two kinds of operating conditions. For the test at 30 V, both electric and flow rate peaks were both observed when the sludge cake dryness was around 30%. The flow rate increased because the current intensity increased sharply and then decreased because of the decreasing electric current and the increasing dryness, respectively. When the electric current decreased to 250 mA, both experiments gave a similar flow rate. This study points out the possibility to explain the kinetics of tests conducted under constant voltage condition with the same kind of analysis than the one used for tests conducted under constant current.

CONCLUSION

Several conclusions can be stated from this work:

- For a given cake dryness a higher current intensity leads to a higher mass flow rate of filtrate.
- For a given current intensity, higher cake dryness leads to a lower mass flow rate of filtrate.
- When operating at constant voltage the current intensity changes and exhibits a peak. This peak is correlated with the peak observed on the mass flow rate of filtrate
- The sludge loading does not affect significantly the flow rate of filtrate provided that comparisons are made at a given dryness and a constant current intensity, respectively. Consequently, a higher sludge load dewaters slower.

REFERENCES

Iwata, M.; Tanaka, T.; Jami, M.S., (2013) *Application of electroosmosis for sludge dewatering-A review*, Drying Technology 2013, 31 (2), 170-184.

Mahmoud A., Olivier J., Vaxelaire J. and Hoadley A. F. A., (2010) *Electrical field: A historical review of its application and contributions in wastewater sludge dewatering*. Water Research, 44(8), p.2381‐ 2407.

Mahmoud A., Olivier J., Vaxelaire J. and Hoadley A. F. A., (2011) *Electro-dewatering of wastewater sludge: Influence of the operating conditions and their interactions effects*. Water Research, 45(9), p.2795‐ 2810.

Olivier J., Vaxelaire J., Conrardy J.-B., Citeau M. and Vorobiev E., (2014) *Electro-dewatering of anaerobically digested and activated sludges: an energy aspect analysis.* Drying Technology 2014, (in press)