Impact of a high linear weight polymer co-conditioning with Polyaluminium chloride on dewatering and convective drying of urban sludge

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Context

Annual production of sewage sludge in Europe is estimated at more than twelve million tons of dry matter. Use in agriculture and incineration are the main ways of valorization. In this context, sludge drying appears as an essential step after mechanical dewatering. It reduces the costs of storage and transport, allows the stabilization and the hygienization of sludge while increasing its calorific value. However, at the end of wastewater treatment process, liquid sludge is a colloidal system in which particles form a stable suspension in water, making it difficult to be separated from water. The addition of polyelectrolyte chemical is necessary to help the sludge particles to agglomerate into large flocs that can be separated by mechanical dewatering. This work investigated the influences of Polyaluminium chloride (PAX-14) co-conditioning with a high linear weight polymer on the sludge dewatering and drying performances, by using experimental design methods.

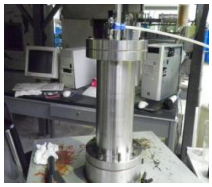
Materials and Methods

Sludge samples conditioning

- WWTP Grosses Battes, Liège, Belgium
- 600 mL of sludge + PAX/ Polymer
- Polymer: CT (6 g/kg$_{DS}$)
- Flocculation in Jar test device:
  - Step 1: 120 rpm, 1 min
  - Step 2: 40 rpm, 3 min

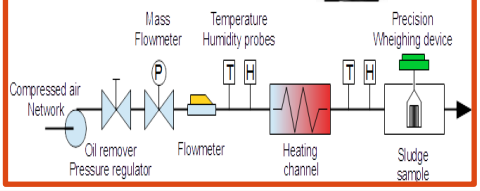
Mechanical dewatering in a normalized filtration-expression cell

- Applied pressure = 5 bar
- Cake dryness = 15-25 %$_{DS}$

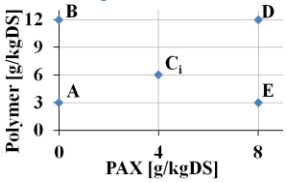


Convective drying tests

- T = 130 °C, V = 1 m/s, Y = 0.005 kg$_{water}$/ kg$_{DA}$
- Cylindrical samples :
  - Height = Diameter = 14 mm
  - Initial weight = 2.5 g



Experimental design



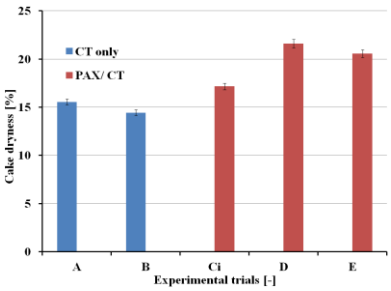
- [PAX]: without, the maximum operational concentration and the middle
- [Polymer] → **C**apillary **S**uction **T**ime : CST$_{min}$ = trial C, the half and the double

Experiments days design

MONDAY	CST [s]
TUESDAY	C_1
WEDNESDAY	A
THURSDAY	B
FRIDAY	C_2
MONDAY	CST [s]
TUESDAY	C_3
WEDNESDAY	D
THURSDAY	E
FRIDAY	C_4

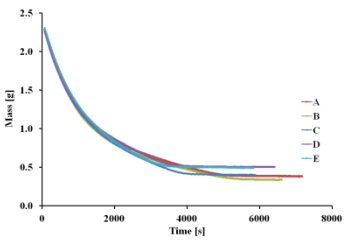
Results

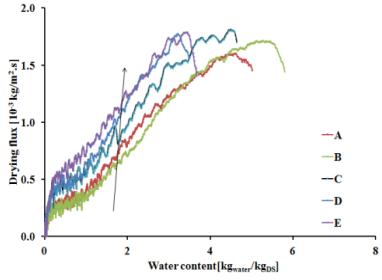
Impact of sludge conditioning on the dewatering process



- Increasing of cake dryness in presence of PAX addition
- The dual PAX/CT improves the dewatering step and reduces energy consumption of all the process

Impact of conditioning on drying rate





- The mass loss curves express the decreasing of the mass samples versus time. The general shape of the curves is the same for all drying tests
- The curves show that D and E samples final weights are higher than the others, depending on initial moisture content.

- Krischer's curves represent the drying flux versus water content
- The dual PAX/Polymer has a beneficial effect on drying by increasing the drying flux

→ For the same water content, drying rate is higher for the samples with PAX added

Time 95%: time to reach 95% of dryness
Average drying rate: total evaporated water divided by time 95%
Drying efficiency: ratio between average drying rate of the considered point divided by average drying rate of central point (C)

Trials	Water content [kg$_{water}$/kg$_{DS}$]	Total evaporated water [g]	Time 95% [s]	Average drying rate 10^{-4} [g/s]	Drying efficiency [-]
A	5.26	2.01	5030	3.99	0.73
B	6.04	2.04	5265	3.88	0.71
Ci	4.90	1.97	3612	5.47	1.00
D	3.73	1.88	3615	5.21	0.95
E	3.84	1.89	3450	5.48	1.00

- Without PAX, the drying efficiency falls to 70% from the reference Ci
- With PAX addition, in case of flocculant overdosage, drying efficiency falls only to 95% and in case of underdosage, efficiency is maintained.

→PAX/CT flocculant combination contributes to decrease energy consumption necessary to dry the sludge

Conclusion and Perspectives

Based on a experimental design, this work aims to put in evidence the impact of sludge co-conditioning by Polyaluminium chloride and high linear weight polymer on both dewatering and drying behaviors. Dual PAX and high molecular weight polyelectrolyte improves flocculation and dewatering process in comparison with the polymer only without PAX addition. PAX appears to be profitable to contribute at this mechanism.
Concerning drying, the positive effect of PAX/polymer addition is shown in the drying kinetics. Consequently a decrease of drying time is observed.
Future work will be investigated in order to understand the reasons of drying enhancement and to test other PAX/polyelectrolyte combinations.