Enhanced sludge dewatering and drying comparison of two linear polyelectrolytes co-conditioning with Polyaluminium chloride

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Abstract

Annual production of sewage sludge in Europe is estimated at more than eleven million tons of dry matter content [1]. Use in agriculture and incineration are the main ways of valorization. In this context, drying of residual sludge appears as an essential step after mechanical dewatering. It reduces the costs of storage, transport and allows the sludge stabilization. However, this process is highly energy consuming and still needs to be optimized as it constitutes an important economic and environmental issue [2].
Polymers are usually employed in the conditioning step in order to promote particle aggregation, making the dewatering easier. The past decades, the application of pre-hydrolized polyaluminium chlorides (PACls) as coagulant has increased, particularly in China, Japan, Russia and Western Europe [3]. As a consequence, PACls are extensively investigated for their coagulation performance, characterization and speciation [3].
In this work, the influence of Polyaluminium chloride (PAX-14) co-conditioning with linear polyelectrolytes on sludge dewatering and drying performances was investigated.
Experiments were conducted on activated sludge samples collected after thickening from the wastewater treatment plant of the Grosses- Battes (Belgium). Two cationic polymers were tested, each of them in combination with PAX for sludge flocculation prior to mechanical dewatering and their effects on sludge convective drying. The one referenced as 640 LH was a linear polymer with a low molecular weight, whereas the 640 CT was a linear one with a high molecular weight. After conditioning, the dewatering step was realized by using a normalized filtration-expression cell (AFNOR 1979) under 5 bar of pressure. Then, the specific resistance to filtration was determined from the follow-up of filtrate mass with time, using the Carman-Kozeny equation [4]. Figure 1 shows the experimental design.

For convective drying experiments, the cake recovered after filtration was extruded through a circular die of 14 mm diameter and cut at a height of 14 mm, yielding cylindrical samples with mass of approximately 2.5 g, as used in several industrial belt dryers. Individual extrudates have been dried in a specially designed convective micro-dryer. Results reported in this paper were obtained with the following operating conditions: air temperature of 130 °C, at ambient humidity (absolute humidity ~ 0.005 kg_{water}/ $kg_{dry\ air}$) and a superficial velocity of 1 m/ s.

Results show that, the dry solids content of the dewatering cake increases with increasing Polyaluminium chloride dosage for both series of experiments. It supposes that PAX contributed to improve solids capture, depicted on Fig. 2. Concerning drying, it appeared that the samples treated by the dual PAX/ polymers combination showed higher drying rates than samples conditioned by polymer without PAX addition, allowing a reduction of the drying time (see Fig. 3). Table 1 shows the drying characteristics of the samples. The drying time decreases and the average drying rate increases with the dual conditioners addition, while the initial water content decreases as well as the total amount water to be removed.

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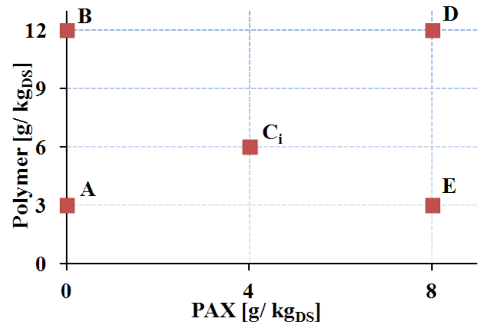

Fig. 1. Experimental design

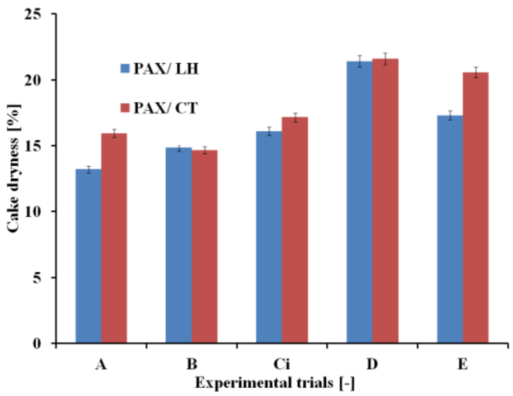

Fig. 2. Cake dryness of the two conditioning ways.

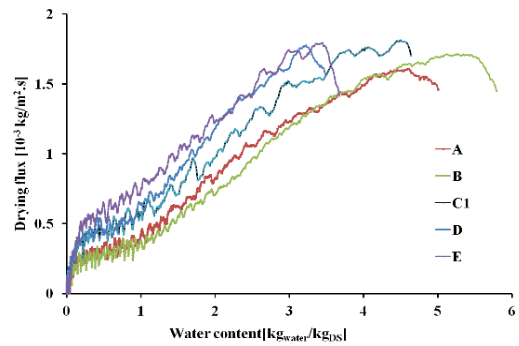

Fig. 3. Krischer's curves obtained by PAX/CT conditioners

Table1: Drying characteristics

	PAX/ polymer dosage [g/ kg$_{DS}$]	Initial water content [g/ kg$_{DS}$]	Total evaporated water [g]	Normalized amount of water [-]	Drying time 95% [s]	Normalized drying time [-]	Average drying rate 10^{-4}[g/s]	Normalized drying rate [-]
PAX 640 LH conditioning	**A (0; 3)**	6.527	2.069	1.000	4850	1.000	4.266	1.000
	B (0; 12)	5.721	2.031	0.982	6100	1.258	3.330	0.780
	D (8; 12)	3.728	1.879	0.908	3155	0.651	5.956	1.396
	E (8; 3)	4.824	1.978	0.956	3640	0.751	5.434	1.274
	C$_i$ (4; 6)	5.007	1.988	0.961	3957	0.816	5.038	1.178
PAX 640 CT conditioning	**A (0; 3)**	5.262	2.005	1.000	5030	1.000	3.986	1.000
	B (0; 12)	6.044	2.043	1.019	5265	1.047	3.880	0.973
	D (8; 12)	3.734	1.882	0.939	3615	0.719	5.206	1.306
	E (8; 3)	3.838	1.892	0.944	3450	0.686	5.484	1.376
	C$_i$ (4; 6)	4.805	1.974	0.984	3612	0.718	5.465	1.371