THE ELECTRO-DEWATERING OF SLUDGE: INFLUENCE OF THE POLYELECTROLYTE DOSAGE AND THE OPERATING CONDITIONS

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1. Introduction

Sewage sludge produced in the EU has reached 13.25 million tons per year [1]. Lately, sludge energy recovery from incineration has drawn considerable attention for its environmental and economic benefits. However, the incineration efficiency strongly depends on the sludge dewatering and drying. On average, mechanical dewatering enables a dry solids (DS) content of 20-30% (wt%) [2], which is not yet enough to achieve a satisfactory incineration efficiency. As an alternative dewatering technique, pressure-driven electro-dewatering (EDW) is shown to be efficient in sludge dewatering and is able to increase the DS up to 40-45% (wt%) [3–5] at a reasonable energy consumption. There are some early attempts to apply economic evaluation to the EDW process, aimed at assessing the feasibility of the EDW process at full scale. Saveyn [6] calculated the payback period, i.e. the time needed to offset the initial capital investment from the cost saving due to the use of EDW. Yuan and Weng [7] considered the EDW cost saving by taking into account the costs of electric energy and those of sludge disposal. However, a more comprehensive evaluation that includes all the relevant aspects, such as the costs of the polyelectrolyte used for the conditioning, the electric energy used for dewatering and the disposal costs, is needed. In this research the influence of the polyelectrolyte dosage and the operating conditions, such as electric potential (V) and sludge cake thickness (CT), on the EDW process of sewage sludge has been studied.

2. Materials and methods

The sludge samples have been taken from four wastewater treatment plants (WWTPs) in the metropolitan area of Milan (Italy), after aerobic (WWTP 1, 2 and 3) and anaerobic (WWTP 4) stabilisation. For the EDW tests, two types of samples have been used: (i) thickened sludge (T), taken before conditioning and (ii) mechanically dewatered sludge (MD). Conditioning tests on thickened sludge were performed in three jar-test beakers, one used as control and the other two operated with two different doses (4 and 8 g/kg_{DS}) of polyamidic, high cationic polyelectrolyte. The EDW tests have been performed in a vertical glass cell (176 mm high, 80 mm inner diameter) by means of a pneumatic cylinder that ensures mechanical pressure on the sludge; its bottom surface acts as anode and is made of DSA® Ti/MMO (Industrie De Nora, Italy). At the bottom of the cell, a PTT filter cloth is mounted above the stainless steel mesh (AISI 304), which acts as cathode. The two electrodes are connected to a DC power supply. To minimise the processing time and avoid leakage of the sample from the cell during the mechanical pressure stage, the thickened sludge samples were preliminarily centrifuged at 4,000 rpm for 5 minutes with a laboratory centrifuge. After that, the samples reached a DS content (DS_{CFG}) of 7.5-13.9% (wt%) and then they were fed into the EDW cell. The procedure of the EDW tests is shown in Figure 1.

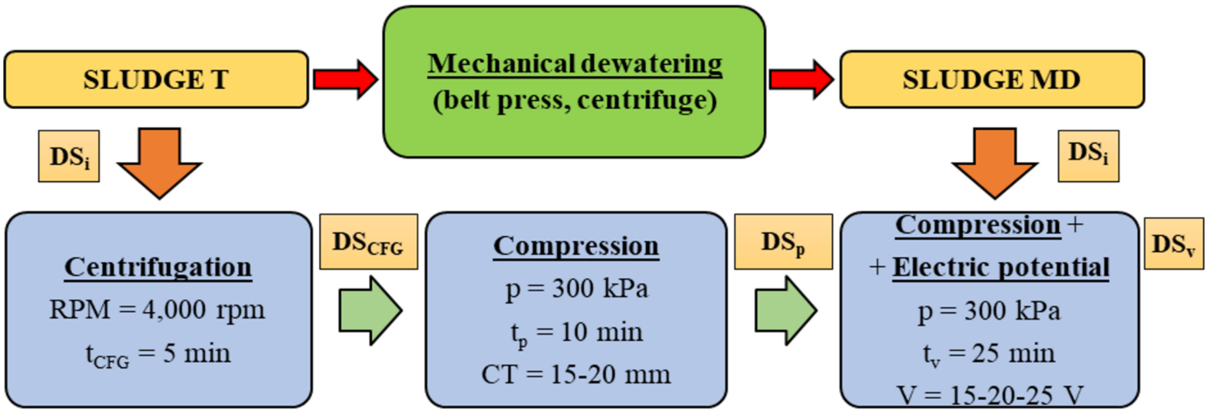

Figure 1 Flowchart of the pressure-driven EDW testing procedure (DS = dry solids).

3. Results and discussion

The results of the EDW tests on T sludge samples are reported in Figure 2. Generally, for aerobically stabilised sludge (1, 2 and 3), the DS content of the conditioned samples obtained after EDW tests was higher than that reached by conventional mechanical dewatering in the four WWTPs (red dotted lines). On average, the DS amount is 4.6% higher for sludge from WWTP 1, 4.1% higher for sludge from WWTP 2 and 12.7% higher for sludge from WWTP 3. However, in case of the anaerobically digested sludge, the DS content obtained in the EDW test overtakes the DS content obtained in the WWTP with mechanical dewatering only at the highest polyelectrolyte dosage. This fact is ascribed to the higher dewaterability of anaerobically digested sludge by mechanical methods, which, in turn, is due to the lower organic fraction.

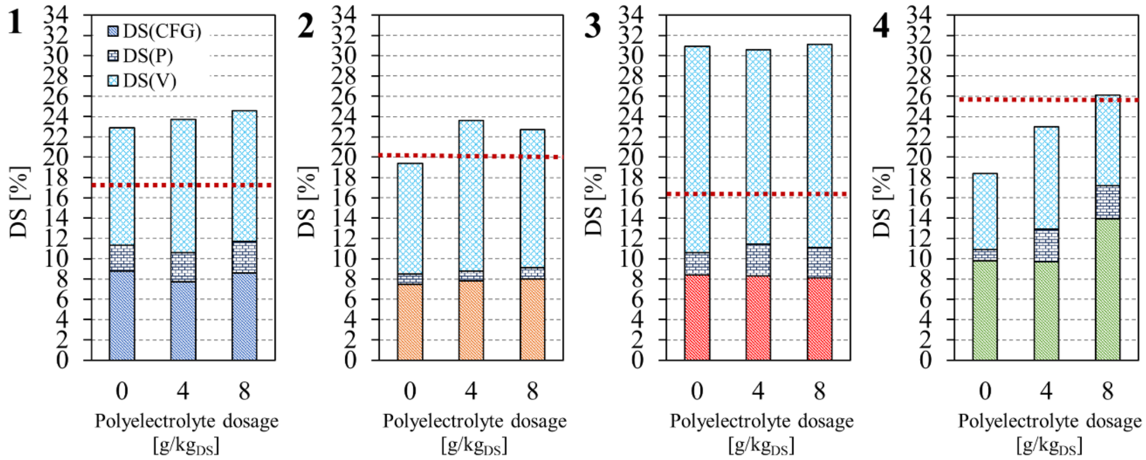

Figure 2 DS content of thickened sludge samples from the four WWTPs after centrifugation at lab and pressure-driven EDW tests at 15 V and 15 mm of cake thickness.

In general, the final DS content of the T sludge obtained with the reference samples was lower than the conditioned sludge at 4 and 8 g/kg$_{DS}$. Indeed, the colloidal and compressible nature of sludge hinders the water removal and the addition of polyelectrolyte is necessary to induce the formation of a network of flocculated particles, resulting in a structure with reduced water retention. Generally, a minimum polyelectrolyte dose is required to induce rapid filtration and obtain a high DS$_p$. However, sludge from WWTP 3 behaves differently, as the final dry solids content (DS$_V$) was not affected by conditioning and the value obtained after EDW was much higher than that after conventional dewatering. Unconditioned sludge from WWTP 3 was furtherly tested by applying different voltages (10, 15 and 20 V). Also, the initial gap from anode and cathode (cake thickness, CT) was set at 15 and at 20 mm: a DS content of 39.3% (wt%) was attained at 15 mm cake thickness and 20 V of

electric potential, that is 21.2% higher than the value achieved by mechanical dewatering. We found out that higher potential values lead to faster kinetics and, thus, to higher final dry solids content. Higher cake thickness increases the electric resistance and thus reduces the efficiency of the process. The results shown on thickened sludge (T) confirmed the feasibility of the EDW process as an alternative treatment to conventional dewatering methods. However, it is worth to study whether this process can be also used as a dewatering method to increase the DS content of sludge already treated by mechanical dewatering with the belt presses or centrifuges commonly used in the WWTPs studied. The four MD sludge samples achieved the highest DS content with tests performed at 20 V and 15 mm of cake thickness, up to 30.1% (wt%), 40.0% (wt%), 38.1% (wt%) and 34.0% (wt%) for the sludge from WWTP 1, 2, 3 and 4 respectively.
The high energy consumption induced by the EDW process, compared to the conventional treatments, may suggest that the use of electric field in a full-scale prototype would not be feasible. However, the reduction in the polyelectrolyte dosage (for T sludge samples) and the increase of the final DS content, with a consequent lower mass of sludge produced, reduce the cost of conditioning and disposal of sludge. Since the sludge disposal accounts for the biggest share in the sludge treatment cost, a higher DS content greatly reduces the total costs of sludge management. This is especially true for the EDW cases treating aerobically stabilised sludge (WWTP 1, 2 and 3). An economic analysis has been performed and the results showed that EDW gave the best performance on the sludge of WWTP 3, where EDW enables a cost saving higher than 30% for T sludge and up to 50% for MD sludge, depending on the operating conditions applied. On the other hand, the high DS content achieved by mechanical dewatering of anaerobically stabilised sludge, without EDW, makes EDW process on T sludge from WWTP 4 unsuitable.

4. Conclusions

EDW will find its best application in medium and small WWTPs, which usually apply aerobic stabilisation and where costly equipment such as filter-press is not popular and the final DS content after dewatering is relatively low.

5. References

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