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# Influence of process operating parameters on dryness level and energy saving during wastewater sludge electro-dewatering

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ABSTRACT

Electrically assisted mechanical dewatering, known as electro-dewatering (EDW), is an alternative emerging technology for energy-efficient liquid/solids separation in the dewatering of wastewater sludge. In this study, the performance of the electro-dewatering (EDW) process for activated wastewater sludge was investigated. The influence of the operating modes; being the timing of voltage (U-EDW) or current (I-EDW) application to either or both the filtration and compression stages, and the influence of the applied pressure (in successive 30 min pressure steps) were studied. The results showed that by delaying the application of the electric field to the filter cake compression stage, there was a potential saving in power consumption of around 10–12% in the case of U-EDW and about 30–46% in the case of I-EDW.

The increase of the applied pressure from 0.5 to 12 bar during the filter cake compression stage leads to an increase in electro-dewatering kinetics. The results also reveal that at a low electric field level the increase of the processing pressure has a relatively pronounced effect on the dewatering process. At high levels of the electric field, a minimum processing pressure (4–6 bar) is required to improve the electrical contact between the electrode and the sludge and thus lower the energy consumption.


## 1. Introduction

During the last decades, the volume of municipal sewage sludge has increased due to the intensification of water purification, and the cost of disposal of this sludge has increased due to more stringent legislation for the protection of the environment. Reducing the cost of sewage sludge (e.g. disposal, transport, storage) depends directly on both the volumes to be treated and their moisture content. The residual water content in the sludge is usually removed by mechanical processes involving gravitational settlers, centrifuges, belt filter presses and plate and frame filter-presses, and further dried, if necessary, by conventional thermal drying. The dewatering efficiencies obtained with wastewater sludge are generally low, 35% (wt% solids on a wet basis) seems to be around the highest value that can be reached even when the sludge is conditioned before dewatering (Chen et al., 2002; Mahmoud et al., 2011). For traditional thermal drying, the energy consumption is proportional to the amount of water which must be evaporated, and both high capital and operating costs are required for water removal from wastewater sludge (Mahmoud et al., 2008; Fytili and Zabaniotou, 2008; Olivier et al., 2014). Therefore, there is a clear need to develop research and innovation in order to improve the conventional dewatering technologies to realize higher final dry solids content with low energy input.

In this context, over the last decade, researchers have devoted considerable efforts either to propose new ideas or to re-visit some old ideas in order to intensify the existing mechanical dewatering (MDW) processes by realizing intelligent combinations of established technologies, such as the addition of a thermal field, an acoustic field, an ultrasound field, an electric field, a microwave field or more recently a hydrothermal effect (Smythe and Wakeman, 2000; Abu-Orf and Hepner, 2005; Clayton et al., 2006; Couturier et al., 2007; Mahmoud et al., 2008, 2010, 2013; Peteers, 2010; Citeau et al., 2012a, 2014, 2016; Tuan et al., 2012; Iwata et al., 2013; Bennamoun et al., 2013; Tunçal and Uslu, 2014; Wang et al., 2014; Ma et al., 2015; Apaolaza et al., 2015).

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Depending on the type of wastewater sludge, the electrical assisted mechanical dewatering, known as electro-dewatering (EDW), is considered as one of the most effective hybrid processes for the improvement of wastewater sludge dewatering efficiency. In the EDW process, an electric field is applied during the conventional pressure dewatering of the sludge to enhance the separation process efficiency with low energy consumption, to increase the final dry solids content and to accelerate the dewatering kinetics (Saveyn et al., 2005; Mahmoud et al., 2010, 2011, 2013; Citeau et al., 2012a; Tuan et al., 2012; Iwata et al., 2013; Olivier et al., 2014; Feng et al., 2014), as shown in Fig. 1. The electrokinetic phenomena involved include the well-known phenomena of electrophoresis, electro-osmosis, and electromigration used to improve the sludge dewaterability. These phenomena have been described in previous works (Mahmoud et al., 2010, 2013) and are depicted schematically in Fig. 1. Fig. 1 represents the MDW process in which suspended solids move towards the filter media to form a cake when mechanical forces are applied (Fig. 1a). It also depicts the movements of suspended solids under the influence of an applied electric field. The suspended solids are usually negative charged particles or anions, also shown is water together with cations (Fig. 1b).

As shown in Fig. 1a,c, during the mechanical dewatering processes (MDW) two stages can be distinguished: the first is the so-called the filtration stage where a filter cake starts to build up and the second is the compression stage where the compressive piston comes in contact with the filtration cake and the cake is compressed into a more compact form leading to a maximum solids content of around 35 wt%. In the EDW process shown in Fig. 1b, three different operating modes are usually used: under constant electric current (I-EDW), or under constant voltage (U-EDW), or even under constant electric field strength (E-EDW). The application of the additional electric field can be applied to either or both dewatering stages, or as a pre-or post-treatment of the dewatering process. For inorganic suspensions or mineral sludge (e.g. kaolinite, bentonite) for which the filtration stage is the dominant step, it is reported that the application of the additional electric field is beneficial from the very start of the dewatering test (Ju et al., 1991; Weber, 2002; Weber and Stahl, 2002, 2003; Larue et al., 2001, 2006). In contrast, for large and compressible sludge (e.g. flocculated activated municipal sludge and flocculated anaerobically digested sludge) for which the mechanical pressure effect may predominate on electrophoresis of particles in the earlier stage, the application of the additional electric field becomes interesting in the compression stage rather than in the filtration one. As the electric field assisted mechanical dewatering of wastewater sludge implies electricity consumption, it is important to carefully decide the starting point for the application of the electric field (e.g. for either or both dewatering stages) in order to maximize efficiency and obtain the most economically feasible process. Friehmelt et al., 1995; Miller et al., 1998; Barton et al., 1999; Lee et al., 2002, Saveyn et al., 2005; Mahmoud et al., 2011, 2013 and more recently Olivier et al., 2015 claimed that, for economic reasons, the EDW stage should be preceded by pressure dewatering. They showed that application of the electric field at the start of the whole dewatering run, at the start of the filtration stage, did not show any beneficial effect to the dewatering result, and that no electrophoretic effects could be observed. This may be related to the fact that the conditioned sludge particle networks are too large to be transported by electrophoresis. Moreover, well conditioned sludge shows a

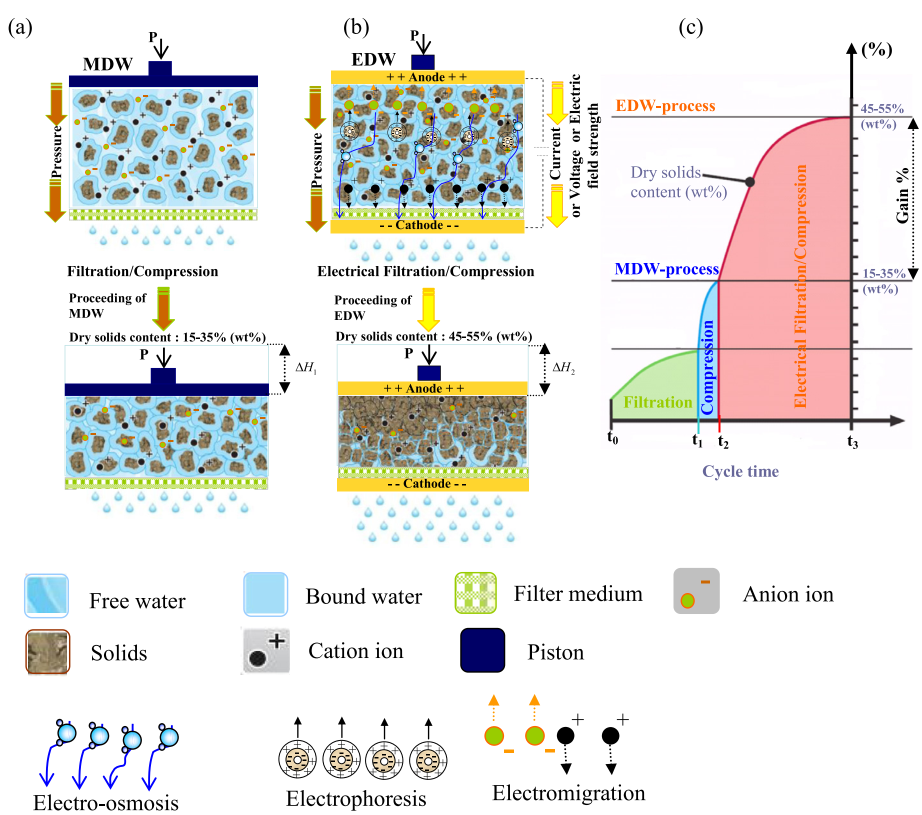


**Fig. 1.** (a) Schematic representation of the different stages in a piston type dewatering device with medium filter at the bottom side of the dewatering device. (b) Schematic representation of electro-dewatering with the different mechanisms occurring when activated sludge is placed in an electrical field (adapted from EMICO Water Technologies CINETIK; Mahmoud et al., 2010, 2011, 2013). (c) Dewatering efficiency in terms of dry solids content (wt%).