Pressure-driven electro-dewatering applied for sludge: Economic & environmental life cycle assessment

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Abstract
Dewatering plays an important role in sludge minimization and reuse. In this study, pressure-driven electro-dewatering (EDW) was investigated using a lab device and various operating parameters were optimised. Furthermore, the EDW system's economic and environmental performances were evaluated using Life Cycle Assessment. These results can be interesting for the stakeholders within the WWTP industry who are considering upgrading from the conventional mechanical dewatering to the EDW.

Keywords
Sewage sludge; Electro-dewatering; Energy consumption; Economic performance; Life Cycle Assessment

INTRODUCTION

Sludge treatment and disposal usually account for half of the operating cost of a Wastewater Treatment Plant (WWTP) (Tomei et al., 2016). Dewatering sludge to a higher Dry Solids content (DS) enables cost saving as well as reduces the environmental impacts of WWTP. To date, mechanical dewatering of sludge is still being widely used and, it only enables to achieve a dry solids content of 20-30%. Recent works show that pressure-driven electro-dewatering (EDW) can further lift the DS to 40-45% (Visigalli et al., 2017). However, when it comes to technology upgrade for a WWTP, apart from the issue of technical feasibility, economic and environmental performances are also important factors to consider (Tomei et al., 2016). Therefore, in this study the EDW was evaluated using LCA with the aim to provide a holistic picture of the system.

MATERIALS & METHODS

EDW was investigated using a lab scale device following the method described in the previous study by Visigalli et al. (2017). The sludge samples were supplied from four different WWTPs around the metropolitan area of Milan (Italy), including samples with and without mechanical dewatering treatment. The operating parameters were optimised by tracking the dewatering rate and current density along the treatment process.

RESULTS AND DISCUSSION

The effects of sludge type (aerobically and anaerobically stabilised), polyelectrolyte dosage (0, 4 and 8 g/kg dry matter), feeding cake thickness (15 and 20 mm) and applied electric potential (10, 15 and 20 V) were evaluated. The energy consumption of EDW was derived from the lab tests and compared with site-specific reference data.

Furthermore, a comprehensive economic assessment was carried out by considering two possible configurations: (1) EDW replacing the mechanical dewatering, (2) EDW as post-treatment arranged after the mechanical dewatering. Promising results were found in both configurations. As partly shown in Figure 1, for the best performance case (sludge samples from WWTP3, under the condition of 15 mm cake thickness and 15 V potential), upgrading to EDW will help the WWTP to reduce its sludge treatment cost (per cubic meter) by 37% and 45%, respectively.

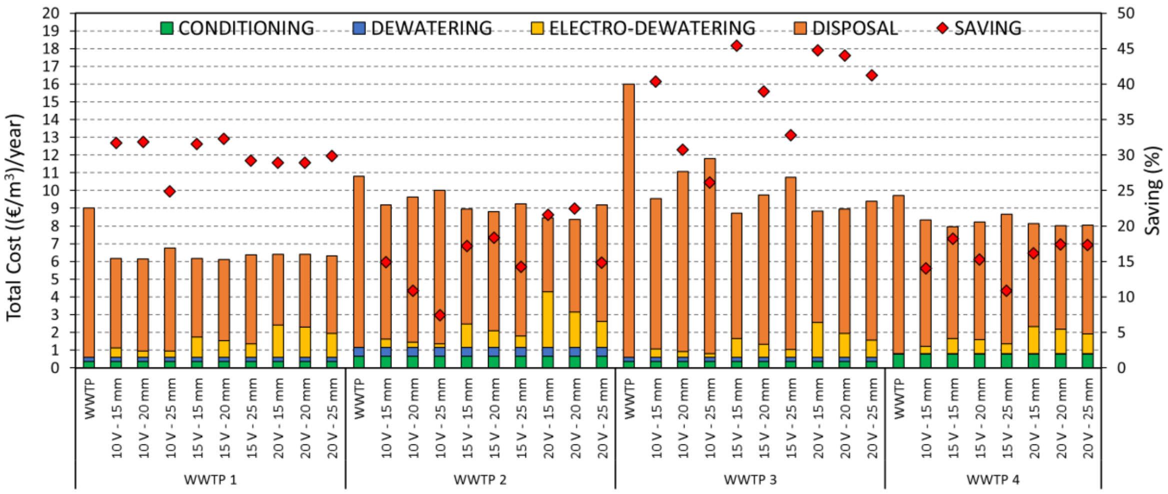

Figure 1. Cost calculation for the configuration where EDW is used as post-treatment after the mechanical dewatering. The saving is calculated as the difference between the reference and the case after technology upgrade.

In addition, the environmental profiles of different technology configurations were assessed using LCA, reporting the net environmental impact, Global Warming Potential (GWP), Acidification Potential (AP), Eutrophication Potential (EP), and energy consumption. Attention was paid to the trade-off relationship between the additional energy input for the EDW system and the enhanced dewatering characteristics (e.g. reduced polyelectrolyte dosage, reduced transport cost and enhanced product quality for both agriculture use and incineration).

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