

Electrodialytic valorisation of sewage sludge and its ashes – potential of phosphorus recovery

Paula Guedes^{1,2}, Nazaré Couto^{1,2}, Eduardo Mateus¹, Lisbeth M. Ottosen², [Alexandra B. Ribeiro](#)¹

¹CENSE, Departamento de Ciências e Engenharia do Ambiente, Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa, Caparica, Portugal

²Department of Civil Engineering, Technical University of Denmark, Lyngby, Denmark

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Presenting author email: abr@fct.unl.pt

Phosphorus (P) is a macronutrient, indispensable for plant growth. Phosphate rock, its primary source, is non-renewable and is included in the EU 2014 list as one of the 20 Critical Raw Materials. This means that there is a need to re-assess current use of P and the potential to recover it from ‘waste’ and reuse it in various applications.

The electrodialytic (ED) process is a technology based on the combination of the electrokinetic movement of ions and electrodialysis through the use of ion exchange membranes. The major aim in using the ED process to recover P from the waste matrices is the possibility to separate it from contaminants present in the source matrix.

In this work, electro –removal and –recovery techniques were applied to sewage sludge (SS) and its ashes (SSA) aiming P recovery and contaminants removal (e.g. emerging organic pollutants and heavy metals). A total of five ED cell designs, based on three compartment cell (3c) and/or two compartment cell (2c), were tested with the SSA and SS. Overall, the data supports that the selection of the cell design should be done case-by-case.

For SSA (Guedes *et al* submitted-a, Guedes *et al* 2014), data supported ED as a viable method to separate P from the heavy metals. P and heavy metals are tightly bounded to the ash, and thus the matrix was suspended in sulfuric acid to increase their solubilisation. Two acid concentrations were tested in two ED cell designs: 2c-cell (Ottosen *et al* 2014) and 3c-cell (Jensen and Villumsen 1995), by applying 50 mA (0.10 mA/cm² for the 2c-cell, 0.08 mA/cm² for the 3c-cell). Independently of the cell design, a higher acidic concentration allowed a higher P solubilisation. The highest P solubilisation and recovery from the SSA was achieved in the 2c-cell (up to 99% of P solubilised using H₂SO₄ 0.19M; 93 and 97% recovery for a fresh and deposited SSA, respectively), in which the SSA was placed in the anode end and a cation exchange membrane was used (Figure 1a). In this design the heavy metals electromigrate to the cathode end being therefore separated from the P that stays in the anode.

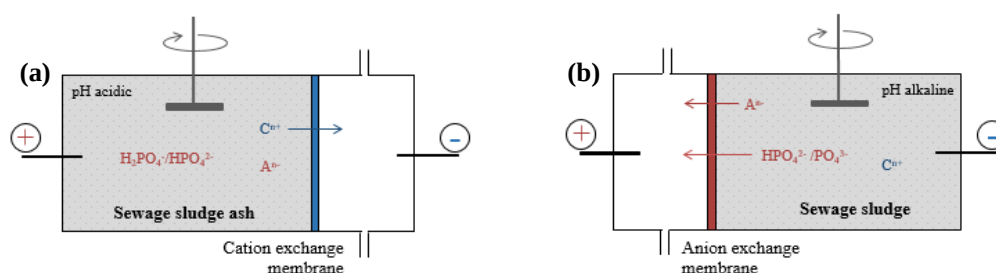


Figure 1. Scheme of the best electrodialytic cell design, two compartment cells, used with the (a) SSA and (b) SS.

The application of a low level DC improved the degradation of emerging organic contaminants (spiked matrix) in the SS while allowing P recovery (Guedes *et al* submitted-b, Guedes *et al* 2015). In contrast to the SSA, a high pH favoured P solubilisation from the SS. The 2c-cell design in which the SS was placed in the cathode end using an anion exchange membrane was the best option (Figure 1b). This design allowed the migration of P to the anode end. In total, 78% of P were recovered after 5 days using 50 mA (0.10 mA/cm²) and 70% of P in 3 days using 100 mA (0.21 mA/cm²). Still, the obtained results showed that 55% were recovered in 24 h using 100 mA. This suggests that P recovery, for the studied experimental conditions, should be carried out only for 24 h, decreasing the associated energy costs.

Comparing the two matrices, the highest amount of P was recovered in the SSA, approx. 125 g of P/kg of SSA in anolyte (93 and 97% for the fresh and deposited ash). However, this recovery was achieved after 7 days

of ED treatment. With SS, 31 g P/kg SS (55%) were recovered after 1 day and 40 g of P/ kg SS (70%) after 3 days.

Although ED seems to be a promising technology, more research is needed in order to make the process less time consuming and consequently more economically viable.

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