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Utilisation of electrodialytic treated sewage sludge ash in cement based materials

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Phosphorous (P) is a scarce resource and there is a need to find methods to reuse P from waste materials. In Denmark, a national target for 2018 is 80 % reuse of P from sewage sludge, with focus on extraction from sewage sludge ash (SSA) (Miljøministeriet, 2014). SSA is today disposed of, as the ashes contain heavy metals and in addition, P which is not plant available in the ashes. This calls for new techniques for P extraction and an electrodialytic process has been developed in Denmark (WO2015032903-A1). In the electrodialytic process, P is extracted as phosphoric acid, which can be used in the fertilizer industry. At the same time, heavy metals are removed from the SSA by electromigration of positively charged metal ions over a cation exchange membrane (CEM) as shown in figure 1, leaving a residual ash fraction with a low content of P and .available heavy metals.

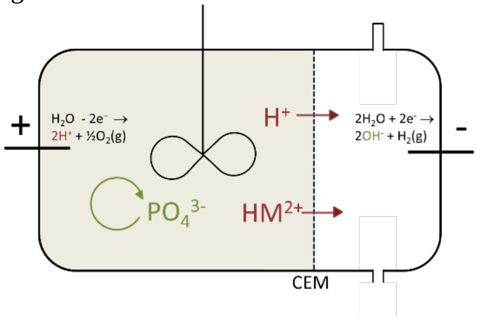

Figure 1. The two compartment electrodialytic set-up for treating a material suspension

The aim of this study was to investigate the potential for electrodialytically treated sewage sludge ash as potential cement replacement in mortar. SSA was sampled from the Avedøre Wastewater Treatment Plant, where P was mainly precipitated by Fe in the wastewater treatment plant, resulting in a reddish SSA. A bench scale electrodialytic experiment, where a suspension of 3 kg SSA and 28 l distilled water was treated for 24 days was made. Total concentrations of P, Cu, Pb, Zn and Cd were measured in the SSA before and after electrodialytic treatment. The untreated SSA ($SSA_{received}$) and electrodialytically treated SSA (SSA_{ED}) were also dry-milled for 30 sec and 10 min prior to use in mortar. The SSAs were used for the production of test binders that consisted of 80 % of cement and 20 %, either $SSA_{received}$ or SSA_{ED}. The basic recipe which was used for the mortar production was 75 % sand and 25 % binder and a water/binder ratio of 0.5. Totally eight mortar samples were made, including two reference samples without cement replacement by SSA. The mortar samples were tested for compressive strength, workability and the color potentials of the red SSA in the mortar was unfolded by casting mortar with smooth and rough surfaces.

The results showed about 90 % electrodialytic extraction of P from the ash and the dissolved heavy metals were removed to the electrolyte. The electrodialytic treatment reduced the pH of the SSA from 9.3 to 3.5, however no immediate influence of the acidic pH of the ash were seen from the results of the mortar testing. Compressive strengths over 55 MPa were achieved for mortars with SSA, although the compressive strength decreased when replacing cement with SSA compared to the reference. Milling the SSA increased the compressive strength of the mortars and there was no significant difference when using SSA_{ED} compared to the $SSA_{received}$. The workability was reduced in the mortars containing SSA compared to the reference, but similarly as the compressive strength, increased when the SSA samples were milled. The red color intensified in the SSA_{ED} compared to the $SSA_{received}$, into a color similar to red bricks. The red color was homogeneous in the entire mortar sample and on both the smooth and rough surfaces.

This study showed potential for electrodialytically extracting P from SSA and utilizing the residual mineral ash in mortar. Future research should include the effects long term durability of adding the acidic SSA_{ED} to the mortars to ensure a sustainable material.

Miljøministeriet, 2014. Danmark uden affald. Ressourceplan for affaldshåndtering 2013-2018.Vejledning fra Miljøstyrelsen nr. 4, 2014 (Report from the Danish EPA)

WO2015032903-A1. Ottosen L.M., Jensen P.E., Kirkelund G.M., Ebbers B.E. Electrodialytic separation of heavy metals from particulate material