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## Phosphorus recovery and heavy metal removal during municipal wastewater treatment

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With current and projected consumption rates, primary sources of phosphorus will rapidly dwindle in the near future and the need for secondary sources will significantly increase [1]. A high potential secondary resource is sewage sludge; however, fertilization of agricultural soil using sewage sludge is often impeded by insoluble phosphorus complexes and hazardous compounds [2], both organic and inorganic of nature.

The formation of insoluble phosphorus complexes is the result of chemical coagulation, a common wastewater treatment method. Iron- or aluminum salts are used to precipitate aqueous phosphorus, mainly present as ortho-phosphates, decreasing phosphorus mobility and significantly restricting recovery from the sludge at a later stage.

Electrodialysis (ED) has the potential to extract the fraction of aqueous phosphorus, normally precipitated, during wastewater treatment. Application of ED in a wastewater treatment plant (WWTP) could eliminate the usage of chemical coagulants altogether. Furthermore, without chemical coagulation and after incineration, the remaining phosphorus in the resulting sludge ash will be more readily available for recovery [3].

Whenever heavy metal concentrations exceed legislative standards, for application on agricultural soil for example, ED can be used to bring heavy metal concentrations below these limits, allowing the sludge to be applied again.

During preliminary research, the removal rates of both phosphorus and heavy metals in relationship to general characteristics of wastewater (sludge) using a 3-compartment (3C) ED cell (figure 1a) was investigated. Samples were obtained from a wastewater treatment plant in Roskilde during different steps in the treatment process.

The results showed that optimal conditions for extraction of phosphorus or heavy metals using ED were found at different locations throughout the wastewater treatment process. Changes in phosphorus removal were mostly influenced by the pH (change) of the sludge; which in turn was related to the buffer capacity. The removal of heavy metals depended significantly on the presence of organic matter (OM); where the removal of heavy metals increased when the amount of OM decreased. Most of the aqueous phosphorus (present as ortho-phosphate's) was effectively recovered.

The goal of this study is to continue the development of ED as treatment method to complement existing wastewater treatment methods and replace chemical coagulation.

In order to create an efficient method, the most important characteristics of wastewater that influence ED efficiency are investigated. This will be done by subjecting wastewater and sewage sludge to ED treatment. The wastewater and sludge will be obtained during different stages of wastewater treatment from various WWTP's in Denmark, employing a variety of wastewater treatment methods, such as oxidative digestion and enhanced biological phosphorus removal.

Lab experiments are performed using a 2-compartment (2C) ED treatment cell where the wastewater sludge is separated from the electrode compartments with ion-exchange membranes. The 2C-setup has shown to significantly improve the heavy metal removal from iron-rich sewage sludge ashes compared to the 3C-setup [4]. For extraction of heavy metals, the sewage sludge will be in contact with the anode and the cathode compartment will be separated by a cation-exchange membrane (figure 1b) while during extraction of phosphorus the sludge will be in contact with the cathode while the anode is separated by an anion-exchange membrane (figure 1c).

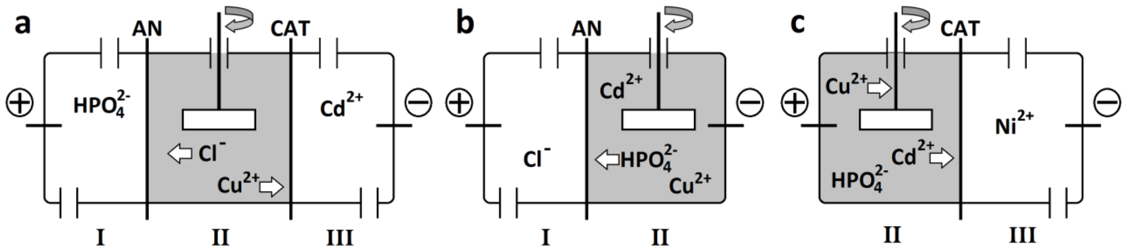


Figure 1. ED cell setup for (a) 3C setup, (b) 2C extraction of HM's and (c) 2C extraction of P, with CAT and AN representing the cation- and anion-exchange membranes, respectively.

The obtained data from this study can be used to asses an optimal placement of ED as technique to recover phosphorus or remove heavy metals in combination with existing wastewater treatment methods. Furthermore, correlating ED extraction of phosphorus or heavy metals against important parameters in the sludge, e.g. organic matter content and pH, will provide important information for improvement of using ED in these situations.

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