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Tailoring residue-derived carbon materials for the removal of wastewater contaminants

Adsorption and surface properties

Mirva Niinipuu

Akademisk avhandling

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Fakultetsopponent: Dr Capucine Dupont,
Department of Environmental Engineering and Water Technology,
IHE Delft Institute for Water Education, Delft, The Netherlands.

Department of Chemistry, Umeå University

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Mirva Niinipuu

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Abstract
The availability of effective, low-cost wastewater treatment is necessary for increased water recycling and the prevention of environmental pollution on a global scale. Adsorption on activated carbons is commonly applied in wastewater treatment, but the high cost of conventional activated carbons limits the use of this technique. Several waste streams, such as the residues and by-products of food processing, agriculture and industrial processes, are currently inefficiently utilized and could be transformed into value-added carbon materials. Re-thinking how waste is utilized could reduce waste handling costs and increase resource efficiency, which would provide both economic and environmental benefits. Therefore, low-cost carbon materials prepared from renewable low-cost resources are an attractive alternative to decreasing the costs of wastewater treatment.

The research underlying this thesis investigated the potential of carbonized residue materials to remove environmentally relevant concentrations of organic and inorganic contaminants from wastewater. The research covered in this thesis included the carbonization of tomato- and olive press wastes, rise husks, horse manure, municipal wastewater sludge and bio- and fiber sludges from pulp and paper mills. The effect of carbonization temperature and starting material was studied in terms of surface properties and contaminant removal to gain knowledge on which surface features are beneficial for the removal of different contaminants. The extent to which different chemical activations of carbonized materials improve the contaminant removal was also studied.

The results demonstrate that carbonized materials are generally quite ineffective at removing organic compounds from water, which may be due to the low surface areas of these materials. Carbonization temperature was shown to alter the surface functionalities of the carbons, more specifically, high carbonization temperatures decreased oxygen-containing surface functionalities that benefitted the removal of most contaminants (which was most pronounced for Zn and trimethoprim). Further experiments investigated the role of the water matrix, and the results unexpectedly showed higher removal from a complex water matrix. Chemical activation improved removal efficiencies for all of the studied compounds, with the most pronounced effects observed for organic compounds. The activated carbons were able to completely remove fluconazole and trimethoprim from the landfill leachate water, and also showed high removal efficiensies (50-96%) of Cu and Zn. Furthermore, the results showed that adsorbate compounds may interact with the adsorbent surface in diverse ways, for example, via properties such as porosity and the presence of oxygen-containing functionalities or minerals. Also, adsorbate hydrophobicity (log Kow) affected the removal of organic compounds in some of the studied hydrochars. The research discussed in this thesis has highlighted that future studies should study the broad range of environmentally-relevant adsorbates through multi-component adsorption systems that include several complex water matrices.

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Adsorption, hydrochar, HTC, chemical activation, wastewater, pharmaceuticals, metals, surface properties, biobased residues

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