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Biochar as a sorbent for chlorinated hydrocarbons – sorption and extraction experiments in single and bi-solute systems

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Biochar (BC) is increasingly deemed a potential sorbent for contaminants in soil and water remediation, and brownfield restoration. In this study, sorption and extraction experiments were performed to assess the potential of three different BCs to sorb and retain the chlorinated hydrocarbons trichloroethylene (TCE) and tetrachloroethylene (PCE). BCs studied were produced from wood chips, grain husk, and cattle manure at 450 °C. A commercially available activated carbon (AC) served as a reference. The sorption behaviour was studied in batch experiments in single solute and bi-solute systems. Resulting isotherms were fitted to the Freundlich model. To assess the desorption behaviour, a five-step extraction scheme (water at 40°C, water at 80°C, methanol at 50°C, toluene at 50°C, and n-hexane at 50°) was developed, utilizing Accelerated Solvent Extraction.
Isotherms revealed distinct differences in sorption behaviour depending on BC feedstock. Sorption capacity ranked as follows: wood chip BC > grain husk BC > cattle manure BC for both contaminants. This sequence could be attributable to an increasing specific surface area, an increasing amount of carbon, and a decreasing ash content of the sorbents. It is noteworthy that all three BCs were more effective in adsorbing TCE, which is surprising, given the higher logKow of PCE. The reverse was observed for the AC. Here, sorption is purely driven by the hydrophobicity of the compound rather than sorbent properties. In bi-solute experiments, PCE sorbed as good as or stronger than TCE, yet the total mass of sorbed compounds increased slightly. In contrast, AC showed a significant decrease of TCE sorption and no significant changes in the total mass sorbed. Extraction experiments revealed that for all BCs a large fraction of the contaminants could not be readily desorbed. In all cases, water remobilized < 5 % of the total contaminant mass and up to 70 % could not be extracted by any of the solvents.
The findings suggest that BC is a promising sorbent for mixed contaminant systems as it offers a diverse nature of sorption sites and is more effective in long-term immobilization than AC.