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Biochar from malt spent rootlets for the removal of mercury from aqueous solutions

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Biochar is receiving increased attention as a promising material in environmental applications. It is obtained from the incomplete combustion of carbon-rich biomass under oxygen-limited conditions. One of the many proposed applications of biochars is the removal of metals (e.g., lead, mercury, etc.) from aqueous solutions. Mercury is one of the heavy metals of particular concern due to its toxicity even at relatively low concentration and thus, its removal from aqueous systems is desirable.

Malt spent rootlets is a by-product formed during beer production, it is inexpensive and it is produced in high quantities. The objective of the present study was to evaluate the potential use of biochar, produced from malt spent rootlets, to remove mercury from aqueous solutions. Batch experiments were conducted at room temperature (25^{o}C) to obtain the optimum sorption conditions under different pH values, biomass dose, contact time, and solution ionic strength. Sorption kinetics and equilibrium capacity constants were determined at the optimum pH value. Furthermore, the effect of different leaching solutions on mercury desorption from the biochar was examined.

All studies with mercury and biochar were conducted at pH 5 that was determined to be the optimum pH for sorption. The proportion of mercury removal increased with the increased dose of the biochar, i.e. from 71% removal for biochar dose of 0.3 g/L, it reached almost 100% removal for biochar dose $\geq$1 g/L. Based on the isotherm data, the maximum biochar sorption capacity (q_{max}) for mercury was 99 mg/g. Based on the sorption kinetic data, (q_{max}) was achieved after 2 h; it should be mentioned that 30% of the (q_{max}) was observed within the first 5 min. Five leaching solutions were tested for mercury desorption (H_2O, HCl, EDTA, NaCl and HNO_3). HCl resulted in the highest extraction percentage of the sorbed mercury. The desorbing mercury percentages at 24 h for HCl concentrations 0.1, 0.2, 0.4, 0.8, and 2 M were 62, 59, 62, 69, and 95%, respectively. Finally, the influence of solution salinity in mercury sorption onto biochar was tested by adjusting the solution ionic strength with two different salts, NaCl and $NaNO_3$. The salts were added at concentrations 1, 0.5, 0.1, 0.01, 0.001, and 0.0001 mol/L. Mercury removal was not affected by the presence of $NaNO_3$ and high metal removal percentages were obtained even at high $NaNO_3$ concentrations (about 53% at concentration 1 mol/L $NaNO_3$). However, a significant decrease of mercury adsorption was observed with the increase of NaCl concentration, i.e. from 55% removal at concentration 0.0001 mol/LNaCl, it reached 20% removal at a concentration of 1 mol/L NaCl. These differences can be related to the different counter ion present in the salts. NO_3^- does not interfere in mercury sorption but Cl^- forms mercury species with negative charge, which do not favor the sorption process. Generally, biochar from malt spent rootlets seemed as a promising novel sorbent that could be used for aqueous system remediation under most environmental conditions.