Functionalizing Biochar with Layered Double Hydroxides for Removal of Phosphate and Nitrate from Aqueous Solutions

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Growing concerns about eutrophication induced by elevated phosphorus (P) and nitrogen (N) levels in water and wastewater demand innovative water quality treatment technologies. My previous research investigated phosphate adsorption by biochar functionalized with Mg-Al and Mg-Fe layered double hydroxides (LDH). The objective of the study is to examine the mechanisms of phosphate adsorption onto LDH/biochar composites in concert with determination of their adsorption of nitrate. Different LDH/biochar composites were synthesized through liquid phase co-precipitation of Mg-Al, Mg-Fe, and Ca-Al LDH with M2+/M3+ ratio of 2:1, 3:1, and 4:1 on varying amounts of biochar. A series of batch experiments along with characterization using scanning electron microscopy (SEM), X-ray diffraction (XRD), and X-ray photoelectron spectroscopy (XPS) were conducted. Results indicate that phosphate adsorption increased with increasing M2+/M3+ ratio for Ca-Al and Mg Fe LDH/biochar composites while the highest phosphate adsorption was found for the 3:1 Mg-Al LDH/biochar composite. The 3:1 MgAl LDH/biochar composite also exhibited continuous P adsorption under sequential exposure to P solution and the P-laden composite desorbed P gradually in deionized water. The Mg-Al and Mg-Fe LDH/biochar composites also exhibited higher adsorption of nitrate than Ca-Al LDH/biochar composite. SEM images confirm that biochar surfaces were covered with LDH, revealing a synergistic effect between LDH and biochar. The XRD and XPS spectra indicate that interlayer anion exchange and surface adsorption dominated phosphate adsorption for Mg-Al LDH/biochar composite. The study has great applications in developing sustainable environmental management strategies to reclaim and recycle N and P from water and wastewater.

Awards Won:
Second Award of $2,000