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The use of waste-based inorganic sorbents for the removal of metalloids from aqueous solutions

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Although there are already several studies dealing with removing metalloids from contaminated waters using different types of sorbents, the use of either direct waste materials or materials synthesized from waste-based sources is still an attractive topic. Therefore, this study used different sludges (iron sludge and pyrolyzed sewage sludge) to prepare individual sorbent materials (Mg-Fe layered double hydroxide and ferrihydrite) or their composites. The source of iron for individual syntheses was acid-leached iron sludge; therefore, one of the goals was also to compare this raw material with newly synthesized materials. The raw and synthesized materials were thoroughly characterized using solid-state analyses (XRD, SEM/EDX, FTIR, XPS) and tested in laboratory and real arsenic and antimony solutions. The initial results of sorption experiments in laboratory solutions at low concentrations showed relatively high efficiency against arsenic for all materials (except raw pyrolyzed sludge). However, there were significant differences for antimony, where the synthesized ferrihydrite and its composite with pyrolyzed sewage sludge were significantly more effective sorbents than the raw iron sludge and other synthesized materials. To get closer to real conditions, the sorption capabilities of the materials were tested in a soil solution obtained by extracting real metalloid-contaminated soil in demineralized water. The results from real solutions confirmed those obtained from laboratory solutions. The highly effective sorbents were again those based on ferrihydrite, especially for antimony. However, it is necessary to mention that lower pH values were observed in the solutions after contact with these materials, especially when compared to the solutions with materials based on layered double hydroxides. In the case of equilibrium experiments at controlled pH conditions (neutral) and different metalloid concentrations, layered double hydroxides showed a significantly higher captured amount of arsenic. However, in the case of antimony, the synthesized ferrihydrite was again the most efficient material, followed by raw iron sludge. Although the materials appear to be highly effective in aqueous solutions, including real soil solutions, subsequent experiments in real soil conditions are necessary to evaluate their real application potential, including the potential ecotoxicological effects of studied materials.