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Phosphate removal from aqueous solutions using slag microspheres

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ABSTRACT

The objective of this study was to investigate phosphate removal from aqueous solutions using slag microspheres produced from converter furnace steel slag (CFSS) via a slag atomizing process. Batch and column experiments were performed to examine phosphate removal efficiency of the slag microspheres. X-ray fluorescence analysis indicated that the slag microspheres were composed of calcium (40.7%) and iron (25.1%) as well as silica (SiO_2), magnesium, aluminum, and manganese. X-ray diffractometer patterns demonstrated that srebrodolskite (dicalcium ferrite, $Ca_2Fe_2O_5$), magnetite (Fe_3O_4), and hematite (Fe_2O_3) were the major constituents of the slag microspheres. Based on kinetic experiments, the reaction reached equilibrium after around 9 h. Based on equilibrium experiments, the maximum removal capacity was 10.95 mgP g^{-1} from the Langmuir–Freundlich isotherm model. When the solution pH was increased from 3.2 to 9.2, the removal capacity decreased by one order of magnitude from 3.16 ± 0.04 to 0.35 ± 0.15 mgP g^{-1}. This indicates that adsorption on metal hydroxide surfaces may play a major role in the phosphate removal process using slag microspheres. The decreasing tendency of removal capacity with increasing pH may be attributed to the surface charge of the slag microspheres, which have a point of zero charge (PZC) of 7.6. These results also demonstrated that nitrate (NO_3^-), chloride (Cl^-), and sulfate (SO_4^{2-}) had minimal effects on the removal of phosphate at anion concentrations ranging from 0 to 100 mM while bicarbonate greatly interfered with the removal of phosphate resulting in a 87% reduction of the removal capacity. In column experiments, a phosphate removal capacity of 2.27 mgP g^{-1} was achieved (initial phosphate concentration = 200 mgP l^{-1}). This study demonstrates the potential use of slag microspheres as granular filter media in flow-through systems for phosphate removal.

Keywords: Slag microspheres; Phosphate removal; Sorption; Batch experiment; Column experiment

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