The Future of Phosphorus for Food Security: Making Media to Recover the Nutrient from Water

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Phosphorus is absolutely essential to all life and one of the main three nutrients used in fertilizers for crop production. Soil would not be fertile enough to grow crops without it and unfortunately, there is no substitute for this nutrient. The main source of phosphorus is from mining rock, which is not a renewable resource. In order to continue advancing the health and food security of our community, phosphorus needs to be recovered from places where it is lost in the supply chain. One opportunity is in recovering phosphorus from water systems that are affected by eutrophication as well as from wastewater rich in the nutrient.

One method for recovering phosphorus from water and wastewater is through adsorption of phosphate onto porous media where it could later be recovered for reuse. In this work, a magnesium porous material was created and tested for its ability to adsorb phosphate from water as well as desorb the phosphate. A material was chosen that has shown success in phosphate adsorption in chronic kidney disease patients. This powder was then made into pellets (5.5 mm in diameter, 17 mm in length) to avoid clogging the system where it could be used with sludge. The additional binder material was added in various weight ratios, 5-20%, to create stability and then the pellet was calcined in the oven at 300 °C to remove some of the binder and create porosity. The overall BET surface area was determined in triplicate to show that the increase in binder material leads to an increase in surface area. Additional characterization was completed using a scanning electron microscope (SEM) and x-ray diffraction (XRD).

Following characterization, adsorption and desorption batch experiments were completed to determine the ability of the various pellets to recover phosphate. The reaction kinetics were modeled using pseudo-first-order and pseudo-second-order models and the adsorption isotherms were modeled with Langmuir and Freundlich isotherms. The pseudo-second-order model and Langmuir model fit best. Based on these, a maximum theoretical adsorption capacity was determined to be around 52 mg/g from kinetics experiments for the pellet with 15% cellulose. The goal was to synthesize a granular material that would be easier to use in a water system than a powder and prove that these pellets were able to adsorb phosphate for potential reuse. This material could then be employed full-scale to help reduce the dependency on phosphate rock for fertilizer and help ensure food security.

Disclaimer

The U.S. Environmental Protection Agency, through its Office of Research and Development, funded and managed, or partially funded and collaborated in, the research described herein. It has been subjected to the Agency's administrative review and has been approved for external publication. Any opinions expressed in this paper are those of the author(s) and do not necessarily reflect the views of the Agency, therefore, no official endorsement should be inferred. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.