Countercurrent stacked floc blanket reactor ↑ (EPA P3 Phase I grant)

Skills: fabrication, process controller, experimental design

Big questions to answer

- What upflow velocity works well for a floc blanket that is made with PACl and no other suspended solids?
- Can flocs be transported in countercurrent flow between floc blanket reactors in series using the venturi effect at the base of the floc blanket connected to the floc hopper from the next floc blankets?
- Do PACl precipitate floc blankets effectively remove fluoride or arsenic?

Introduction

Fluoride and arsenic can be removed by adding PACl to contaminated water and then filtering the water with a rapid sand filter. The PACl precipitate is removed by the sand filter column and the arsenic is adsorbed by the PACl precipitate. One of the disadvantages of this treatment technique is that the PACl precipitate clogs the sand filter over a runtime of a few hours and with a short runtime the loss of water through backwashing is excessive.

The goal of the stacked floc blanket reactor invention is to develop a novel reactor that efficiently removes fluoride and arsenic while reducing the volume of wastewater produced by producing a concentrated solid waste stream.

Filters loaded with PACl precipitate are efficient at removing arsenic (and presumably fluoride) in part because they are plug flow reactors and thus upstream PACl precipitate is in equilibrium with influent contaminant concentration and downstream PACl precipitate is in equilibrium with effluent contaminant concentration. This allows efficient use of the PACl because most of the PACl ends up being in equilibrium with influent contaminant levels and thus the maximum mass of contaminant is absorbed per mass of PACl precipitate.

Floc blankets have the potential to hold a large mass of PACl precipitate without generating high head loss and floc blankets can concentrate flocs in a floc hopper and thus eliminate the need for the wasteful process of backwashing. The disadvantage of floc blankets is that the fluidized bed is completely mixed over the residence time of the flocs. Thus flocs at the top of the floc blanket would include flocs that are in equilibrium with influent contaminant levels and thus the removal efficiency will be poor. To improve performance we propose to have countercurrent flow through 3 floc blankets with PACl injection occurring at the influent to the 3rd floc blanket and the wasted flocs from the 3rd floc blanket being injected through a venturi into the 2nd floc blanket. Similarly the wasted flocs from the 2nd floc blanket will be injected through a venturi into the first floc blanket. The wasted flocs from the first floc blanket will be in equilibrium with the influent contaminant and will be the waste stream from the treatment process.

Tasks

- Do a complete hydraulic design of the venturi system to see if it is viable.

- Design a series of 3 columns. Make sure to keep head loss between columns low so that the venturi can pump the flocs in countercurrent flow.
- Design a tube settler for the last column to reduce the effluent concentration of PACl and contaminant.
- Design a tube flocculator.
- Build floc blankets using PACl and determine if some clay should be added to create a higher concentration floc blanket.
- Run the entire reactor system without an contaminants to see if the hydraulics are designed correctly.
- Add fluoride to the system and measure fluoride removal efficiency.