2016

Phosphate and Selective Anion Removal of Waste Water in Industrial Systems

Daniel Dillon
Virginia Commonwealth University

Campbell McColley
Virginia Commonwealth University

Laura Strukl
Virginia Commonwealth University

Team Members: Daniel Dillon, Campbell McColley, Laura Strukl
Faculty Adviser: Dr. Frank Gupton, Mr. Rudy Krack
Sponsor: ChemTreat, Inc.

Sponsor Mentor: Dr. William Henderson, Mr. Vladimir Djukanovic

CHEMICAL AND LIFE SCIENCE

Phosphate and Selective Anion Removal

of Waste Water in Industrial Systems

CAPSTONE DESIGN EXPO 2016

ChemTreat, Inc.

Background

Phosphorous is an essential nutrient for a functioning water ecosystem, however, heightened levels caused by waste water and agriculture can be damaging. High levels of PO_4^{3-} cause toxic algae blooms, which kill wildlife and contaminate drinking water supplies. Therefore, cheap, efficient phosphate removal systems are beneficial for commercial settings in order to meet governmental standards. Also, similar research and technology can aid in the removal of toxic heavy metals in industrial waste water.

Figure 2: Historical date of phosphate levels in the James River. Data Given by the James River Association

Goals

- Determine optimal methods of using a packed column of solid supported media to remove anions from wastewater. Such anions include phosphate, lead, chromate, and others.
- Evaluate the regenerative ability of different solutions to reuse spent columns.

Methods

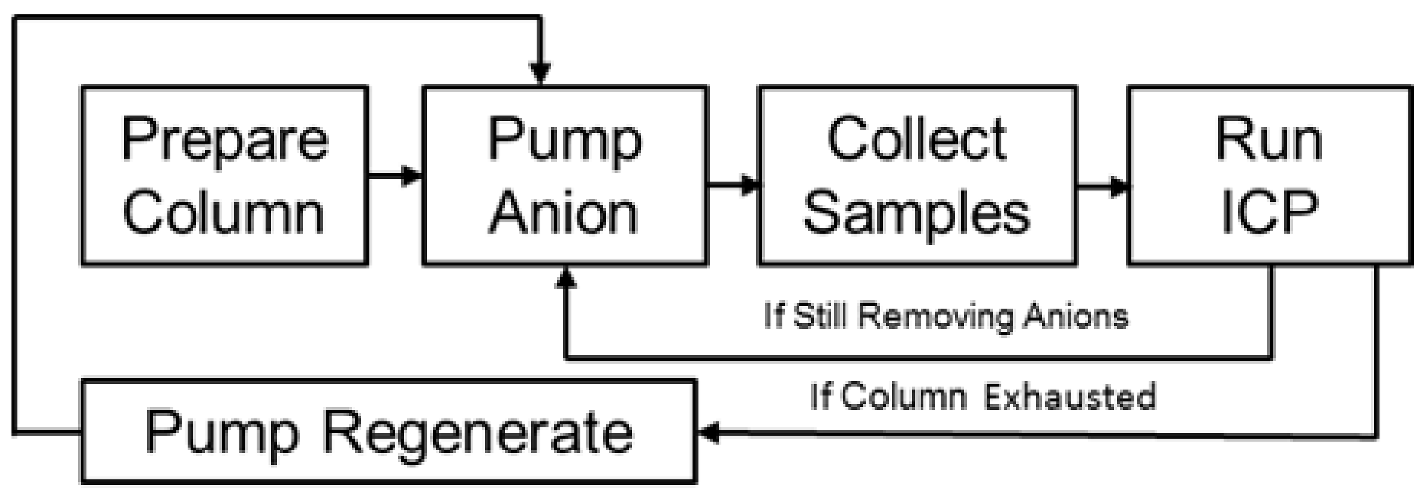

Figure 1:General experimental procedure for both media and regenerate solution studies

Results

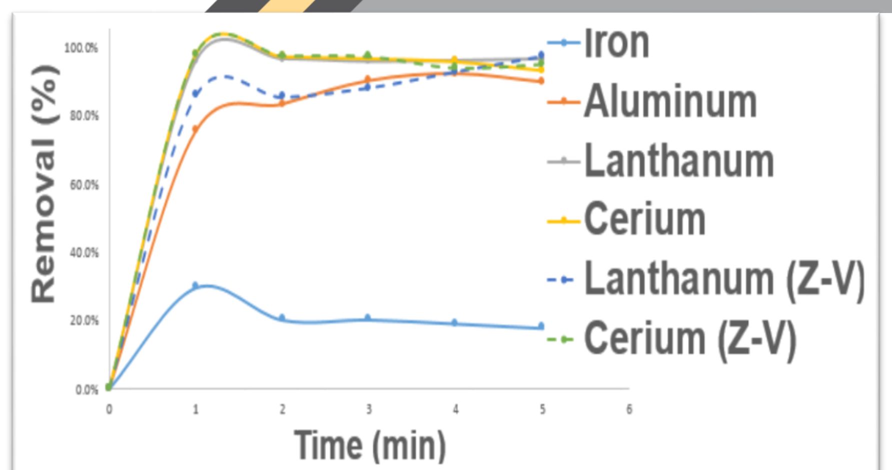

Figure 3: This graph compares the results of the different solid supported metal to media combinations tested for phosphate removal.

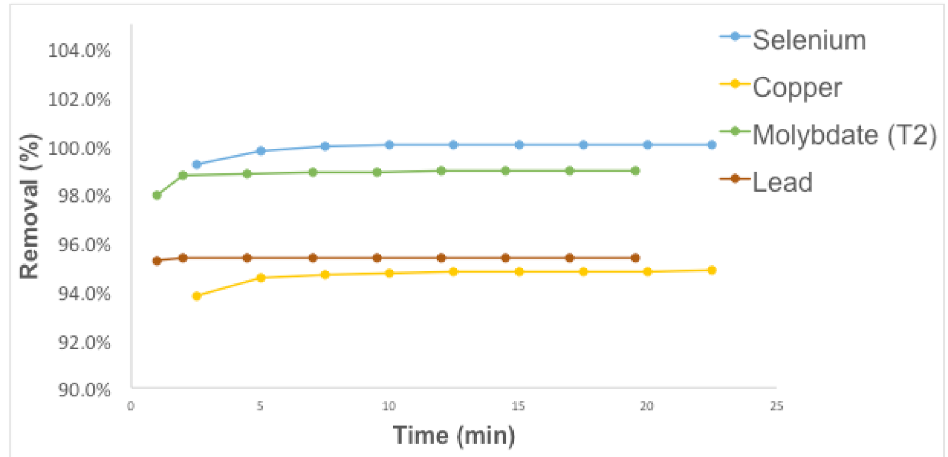

Figure 4: This graph illustrates the effectiveness of heavy metal ion removal using optimal solid supported media approaches.

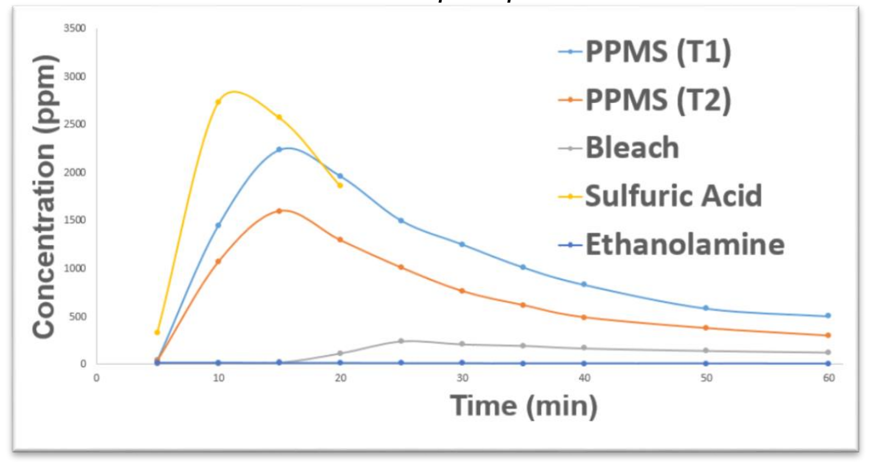

Figure 5: This graph compares the results of the various regenerative solutions used on spent packed columns.

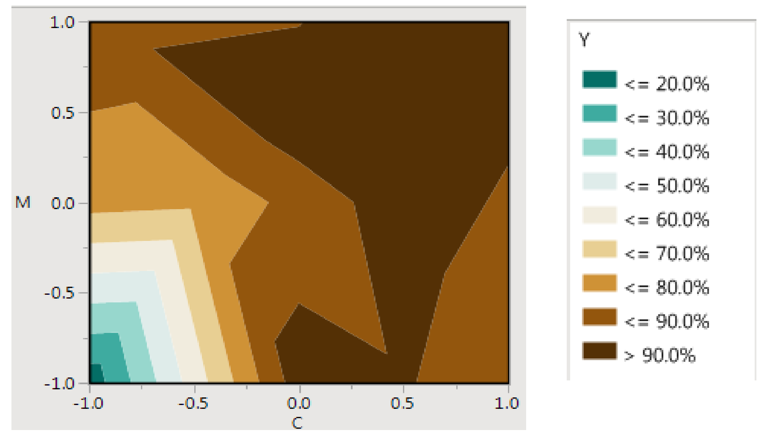

Figure 6: This graph shows the Design of Experiment parameters where C is the contact time and M is the metal loading.

Financial Analysis

Table 1: Comparison of New and Current phosphate removal methods with $CeCl_3$ for treating 10ppm PO_4^{3-} water at 10gpm. *Sludge Only produced in Current Methods.

Chemical Reagent	New Method Reagent Required (kg)	Current Methods Reagent Required (kg)	Comparative Cost of the Reagent	* Sludge Production (kg)	*Disposal cost ($/kg)
Aluminum Chloride	2.5	240	1.60	800-920	30-35
Alum. Hydroxide	0	17	2.28	86-141	3.2-5.3
Ferric Chloride	2.5	20	1.00	46	1.7
Ferric Sulfate	0	104	0.32	240	8.6
Cerium Chloride	3.75	3	1.84	8.8	0.34
Lanthanum Chloride	3.78	3	2.00	8.8	0.34

Proposed Design

The water flows into the column first and recycles through it until anion removal is no longer possible. Once the column can no longer remove phosphate, the controller switches to the regenerate solution stream without recycling until a minimal amount of phosphate (or other anions) are found.

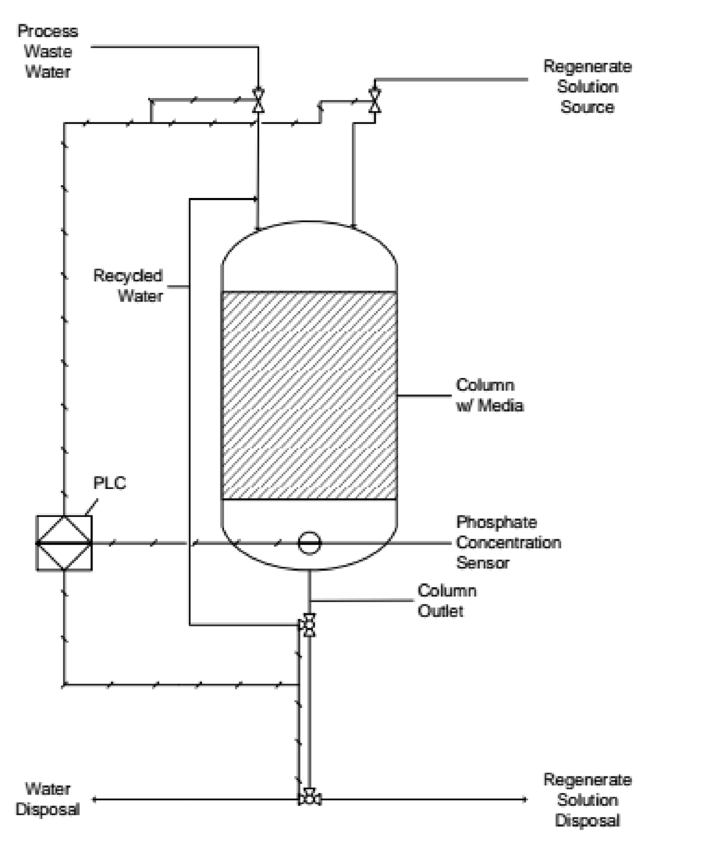

Figure 7: This diagram shows the proposed automated column design system for a scaled up industrial setting.

Conclusions

- The optimal solid supported media was a lanthanum mixture with the highest removal percentage near 100%.
- Both cerium and lanthanum were able to be fully regenerated.
- This system easily removes heavy metal: chromium, selenium, arsenic, lead, molybdate, copper, and nickel.
- Next steps would include testing and finalizing a real time phosphate sensor to the proposed column design.

VCU School of Engineering

Acknowledgements: Thanks to the ChemTreat & Analytical Teams, our Advisors Dr. William Henderson and Mr. Vladimir Djukanovic, as well as our Faculty Advisors Dr. Frank Gupton and Mr. Rudy Krack

Citations:
1. Snurer, Helena. "Sludge Production from Chemical Precipitation" *Department of Chemical Engineering*. Lund Institute Technology.
2. C. James Martel, Francis A. DiGiano and Robert E. Pariseau. "Water Pollution Control Federation)
Vol. 51, No. 1 (Jan., 1979), pp. 140-14.
3. "Comission to Study Methods and Costs of Sewage, Sludge and Spetage Disposal" *HB 699 Chpater 253:1, Laws of 2007: 1-11*

Make it real.