Peat Derived Anion Exchange Materials for Sulfate Remediation in Mine Pit Water

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Abstract: A number of new natural peat derived anion exchange materials were developed in our laboratory. A batch testing of these new anion exchange materials were conducted. Recently we have demonstrated that peat derived anion exchange materials have strong binding affinity to per- and polyfluoroalkyl substances (PFAS). The initial positive results prompted us to investigate their efficiency to remove sulfate anions from mine pit water. Isotherms for chloride to sulfate exchange in a selected material fit Langmuir and Freundlich adsorption models. The practical limiting retention capacity was found to be 108 mg/g for the material (SY2205165) and 167 mg/g for the commercial anion exchange resin (Resinex). The new materials demonstrate their potential for the sulfate removal from the contaminated water sources. Further experiments on evaluation of selected peat lignin derived anion exchange material as well as sulfate selective commercial anion exchange resin in the column environment will be performed for the practical implementation.

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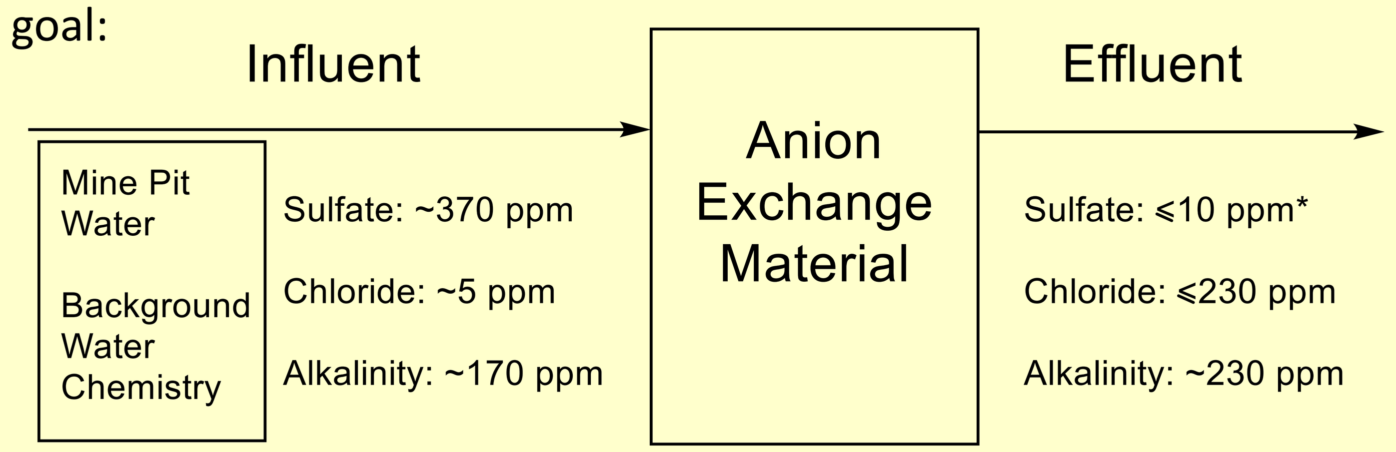
Sulfate Removal Goal

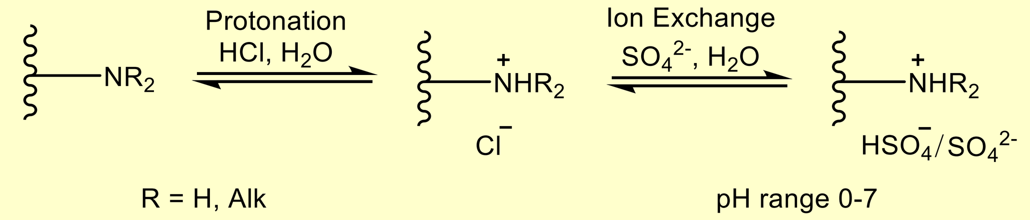
Laboratory goal: Design, development, and implementation of chemical products, processes, and nature derived materials that reduce or eliminate hazardous substances

Project goal:

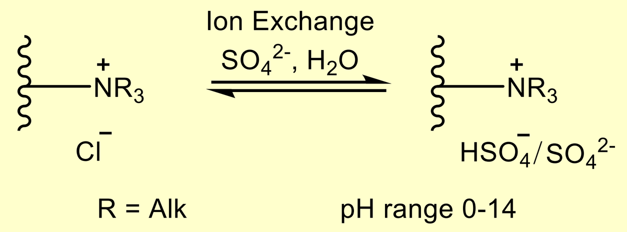


*Minnesota Administrative Rules, 7050.0224 Specific Water Quality Standards for Class 4 Waters of the State; Agriculture and Wildlife.

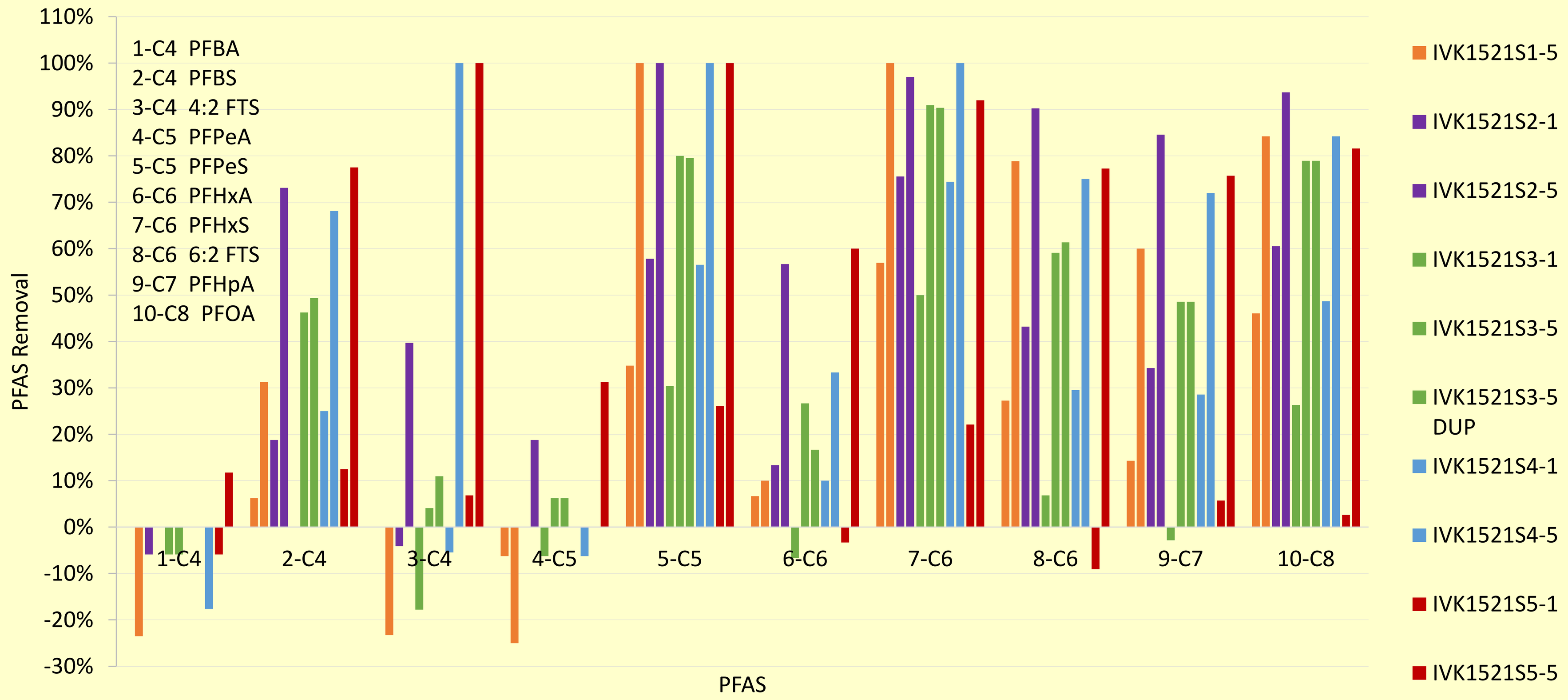
Weak Base Anion (WBA) Exchange Material



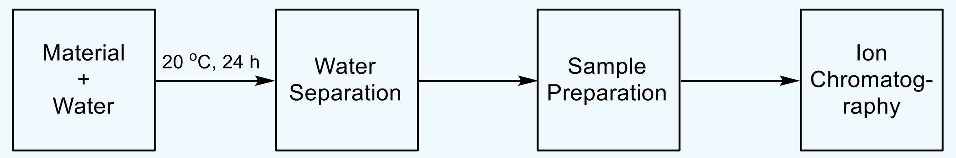
Strong Base Anion (SBA) Exchange Material

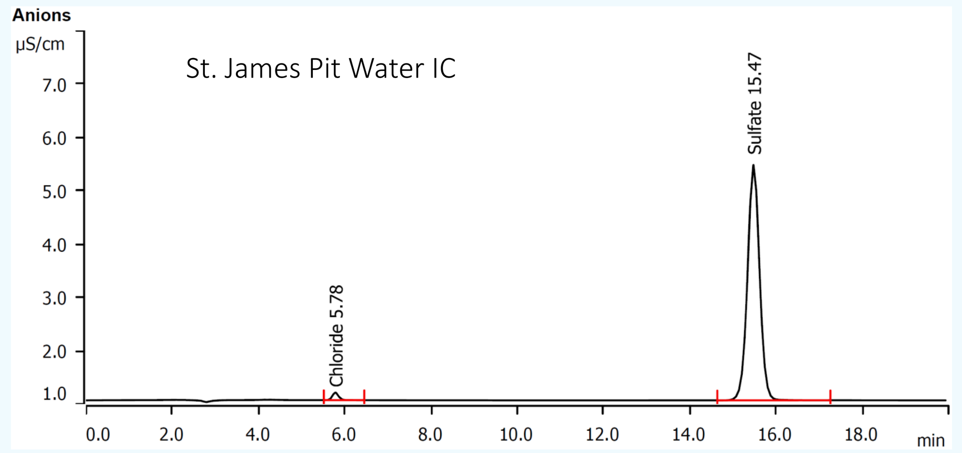


Batch Testing for PFAS Removal from Landfill Leachate



Anion Exchange Equilibrium Experiment

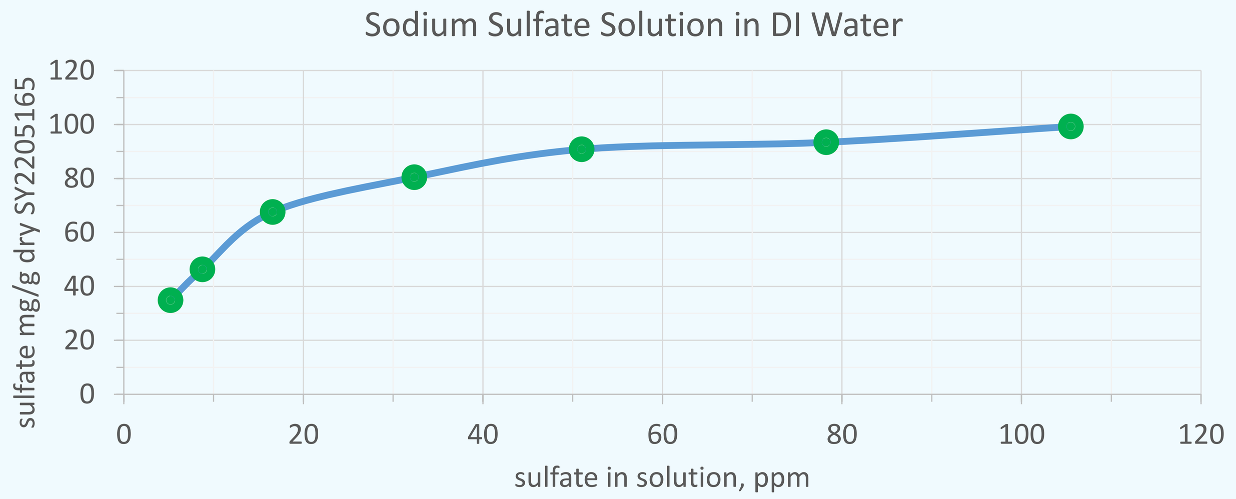




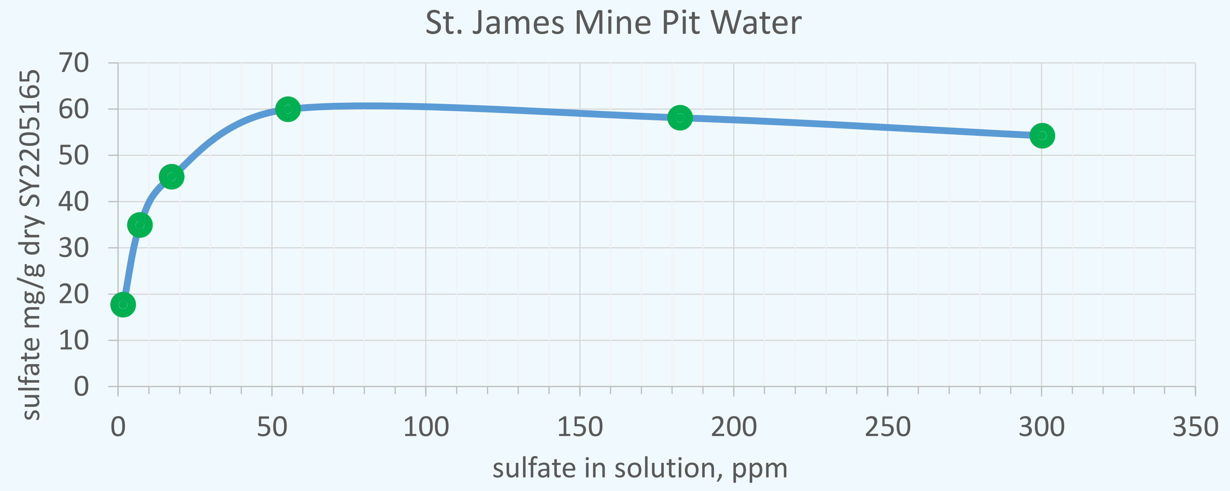
Langmuir Model Isotherm : $q_e = q_{max}\frac{K_L C_e}{1+K_L C_e}$; Langmuir Linear Regression: $\frac{C_e}{q_e} = \frac{C_e}{q_{max}} + \frac{1}{K_L q_{max}}$;
where q_e – ion concentration in the material at the equilibrium, q_{max} – practical limiting ion retention capacity of the material, K_L – Langmuir constant, C_e – ion concentration in the solution at the equilibrium.

Freundlich Model Isotherm : $q_e = K_F C_e^{\frac{1}{n}}$; Freundlich Linear Regression: $log q_e = \frac{1}{n} log C_e + log K_F$;
where q_e – ion concentration in the material at the equilibrium, K_F – Freundlich constant that is an indicator of the ion retention capacity of the material, n – constant related to the affinity of the ions to the material.

Equilibrium for Sulfate in Water with Peat Derived Strong Base Anion Exchanger (SY2205165) and Influence of Background Water Chemistry

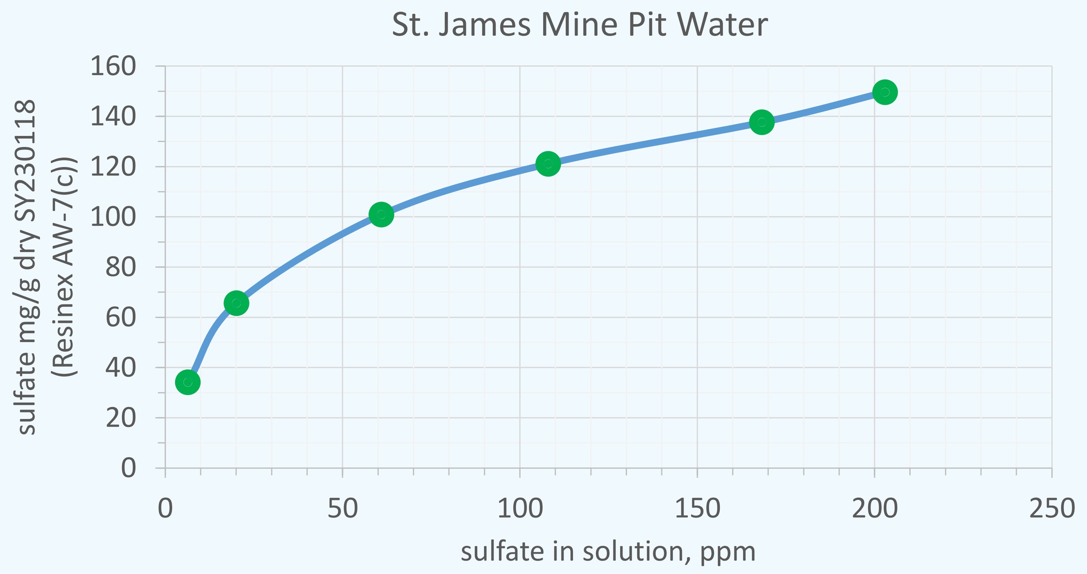


Model for Isotherm	Isotherm Parameters at 20 °C	
Langmuir	$q_{max}, mg/g$	107.527
	$K_L, L/mg$	0.095
	R^2	0.999
Freundlich	$K_F, mg/g$	20.975
	n	2.939
	R^2	0.935



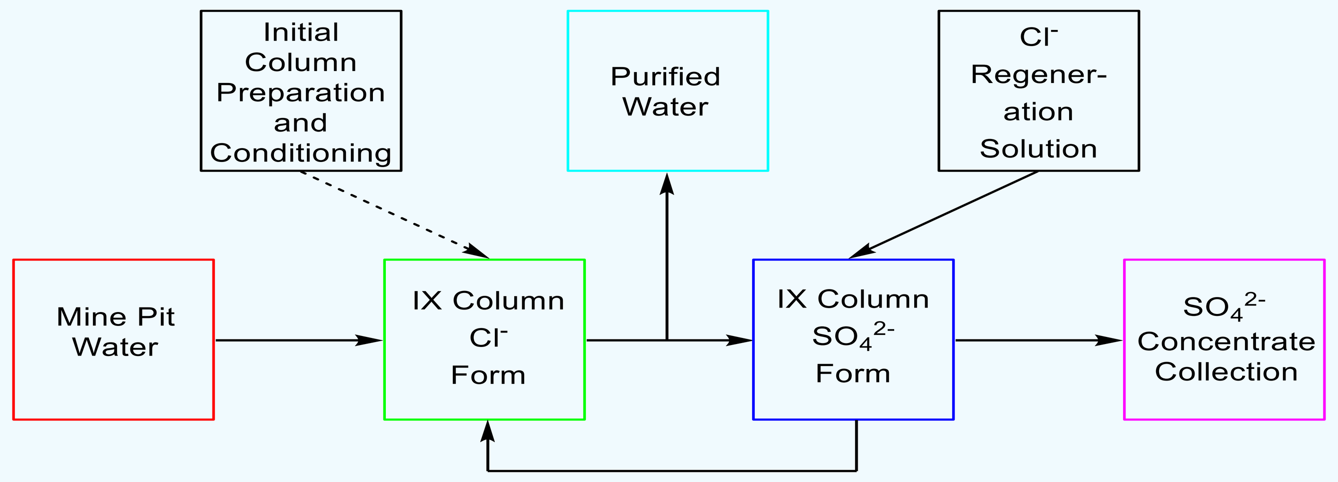
Model for Isotherm	Isotherm Parameters at 20 °C	
Langmuir	$q_{max}, mg/g$	55.556
	$K_L, L/mg$	0.811
	R^2	0.998
Freundlich	$K_F, mg/g$	20.493
	n	4.760
	R^2	0.791

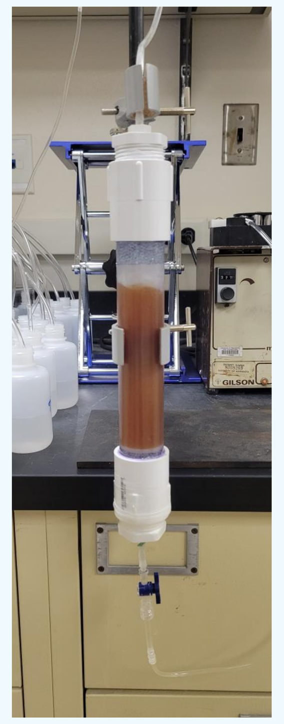
Equilibrium for Sulfate Selective Commercial SBA Resin (Resinex AW-7(c)) with Water from St. James Mine Pit Lake



Model for Isotherm	Isotherm Parameters at 20 °C	
Langmuir	$q_{max}, mg/g$	166.667
	$K_L, L/mg$	0.030
	R^2	0.991
Freundlich	$K_F, mg/g$	17.231
	n	2.414
	R^2	0.985

Column Experiment Design





Conclusions

- Anion exchange equilibrium experiments have shown that peat derived anion exchange materials have a potential for the sulfate removal from the mine pit water.
- The practical limiting retention capacity was found to be 108 mg/g for the peat derived anion exchange material (SY2205165) and 167 mg/g for the commercial anion exchange resin (Resinex).
- Further experiments on evaluation of selected peat lignin derived anion exchange material as well as sulfate selective commercial anion exchange resin in the column environment will be performed for the practical implementation.