Uptake Kinetics of Heavy Metals from Water Using a High Surface Area Supported Inorganic Metal Oxide

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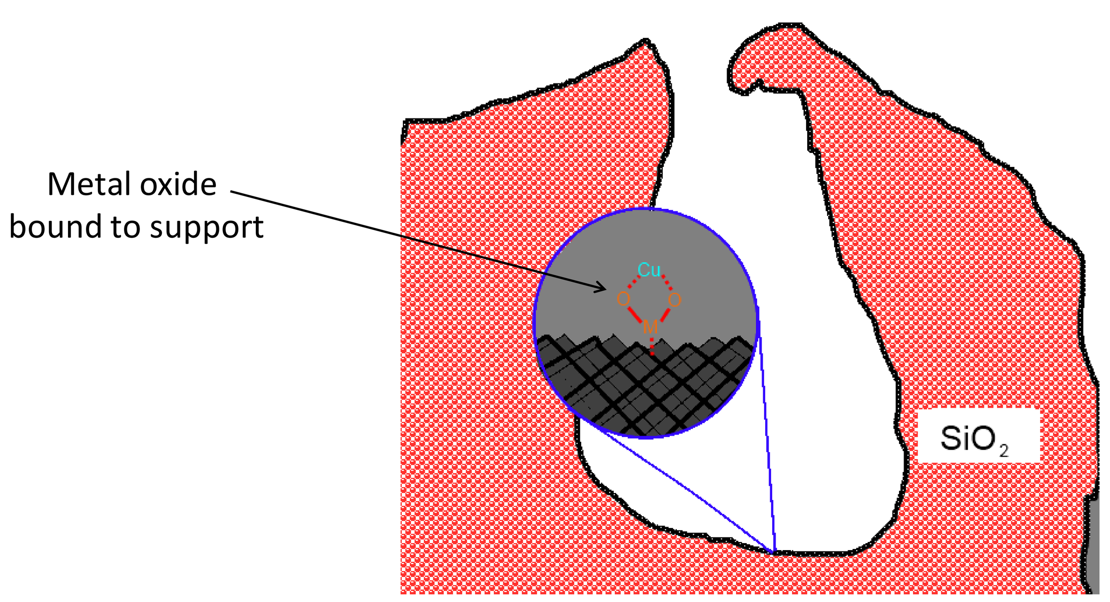
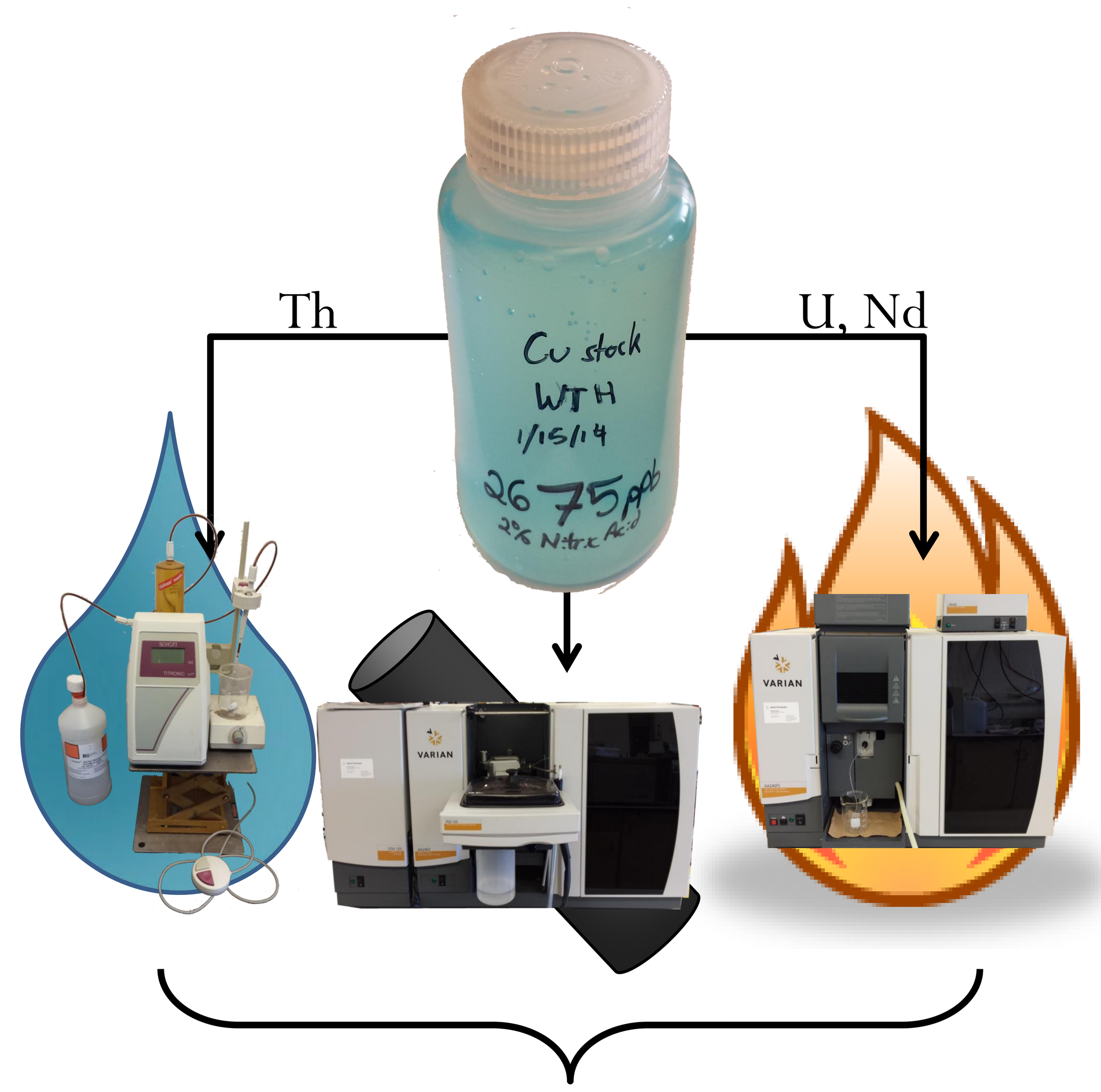
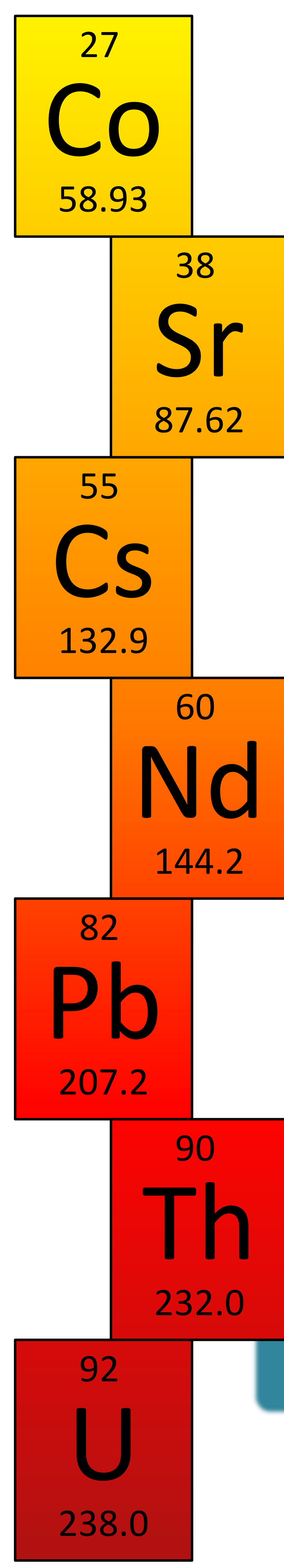
Abstract

Efficient removal of radionuclides from water is extremely important given recent events, such as the Fukushima nuclear disaster. Supported calcium-containing inorganic metal oxide may be able to rapidly exchange with radionuclides from an aqueous environment. The feasibility studies were performed and the uptake kinetics of cobalt, strontium, cesium, neodymium, lead, thorium, and uranium from solution were measured. The uptake and rate constants were determined using pseudo-first order and pseudo-second order rate laws. The applicability of these rate law models to the system was compared and contrasted to other models, notably Langmuir and Freundlich adsorption models.

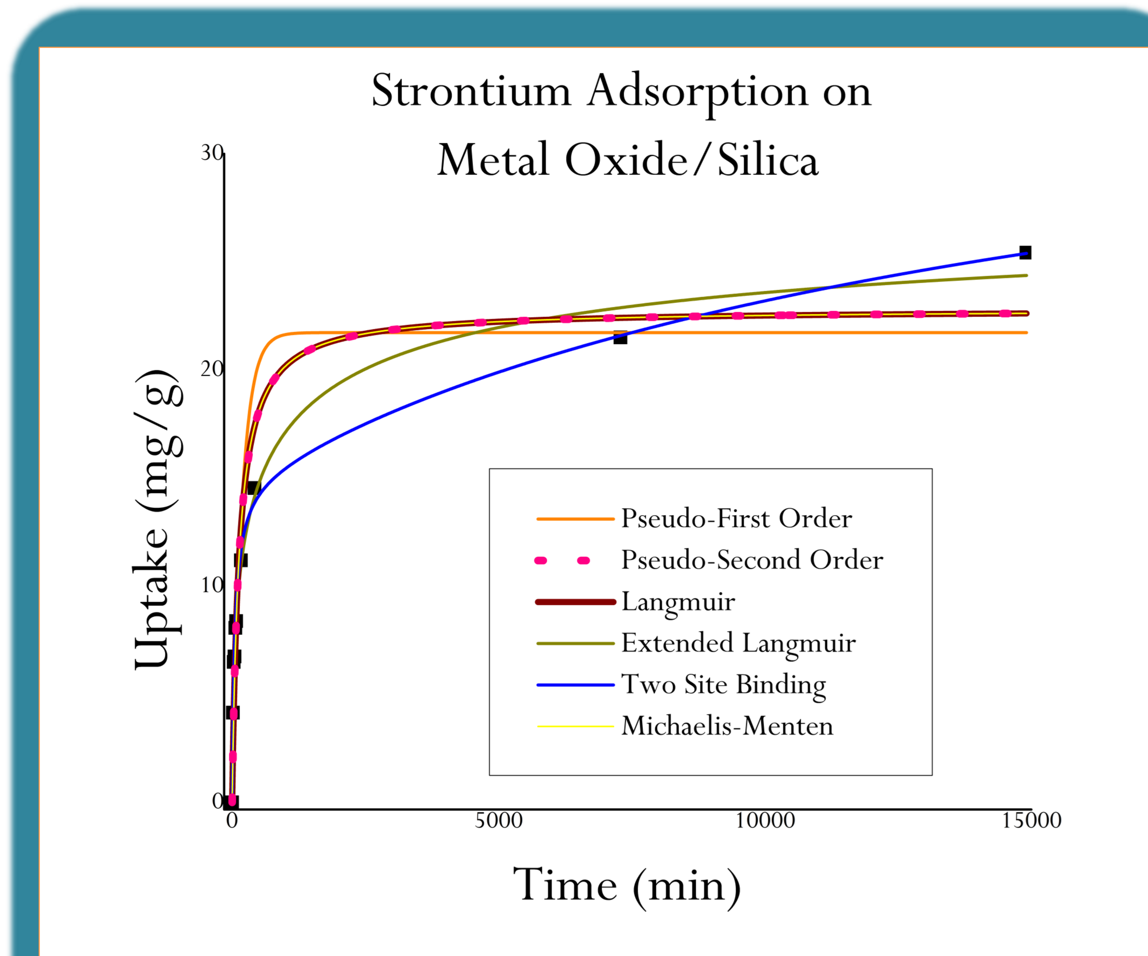
Methods

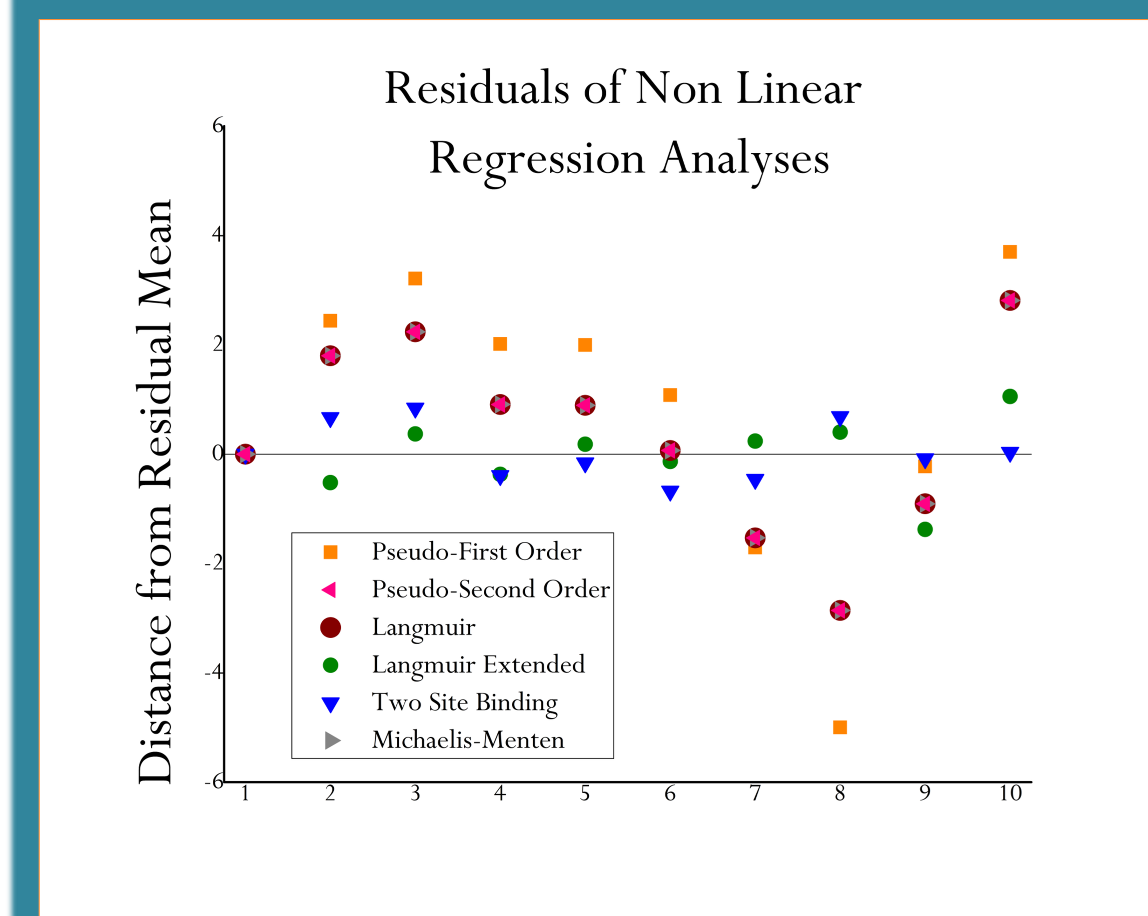






Results and Discussion





	Reduced χ^2	r^2
Pseudo-First Order	8.3857	0.86317
Pseudo-Second Order	3.6397	0.94061
Langmuir	4.1597	0.93213
Extended Langmuir	0.63701	0.98803
Two Site Binding	0.41442	0.99324
Michaelis-Menten	3.6397	0.94061

Pseudo-First Order

$$q_t = q_e(1 - e^{-k_1 t})$$

Pseudo-Second Order

$$q_t = \frac{q_e^2 k_2 t}{1 - q_e k_2 t}$$

Langmuir

$$q_t = \frac{q_e k t}{1 - q_e t}$$

Langmuir Extended

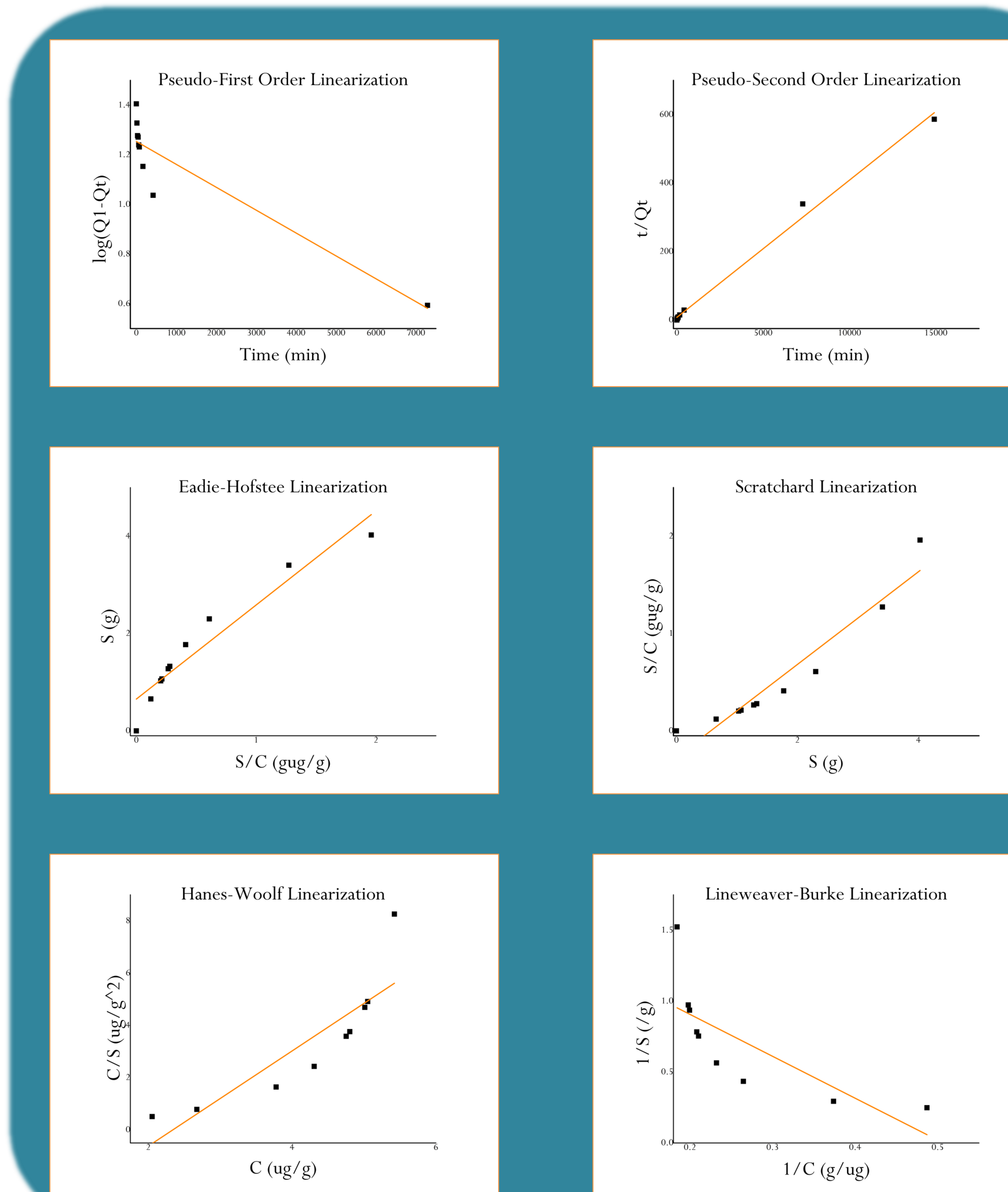
$$q_t = \frac{q_e k t^{1-c}}{1 - q_e t^{1-c}}$$

Two Site Binding

$$q_t = \frac{\beta_{max\,a} t}{k_a + t} + \frac{\beta_{max\,b} t}{k_b + t}$$

Michaelis-Menten

$$q_t = \frac{q_e t}{k_m + t}$$



	Residual $\sum$ Squares	Pearson's r	r^2
Pseudo-First Order	0.06924	-0.92183	0.82830
Pseudo-Second Order	2025.4	0.99718	0.99367
Eadie-Hofstee	1.0947	0.95959	0.91092
Scratchard	0.26964	0.95959	0.91092
Hanes-Woolf	11.589	0.86787	0.71794
Lineweaver-Burke	0.54053	-0.75803	0.51383

Conclusions

	Mw g/mol	Rel. Mass Abs. mg/g	Rel. Moles Abs. μmol/g	Rate Constant g/mgmin
Cobalt	58.93	93.9	1594	7.03E-01
Strontium	87.62	30.3	346	3.09E-04
Cesium	132.9	77.1	332.3	3.72E+00
Neodymium	144.2	183	788.4	5.65E-04
Lead	207.2	83.8	361.1	2.47E-01
Thorium	232	244	1050	6.30E-04
Uranium	238	434	1872	2.16E-04

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