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Characterization and testing of adsorbent materials to extract uranium from natural seawater

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A marine testing and characterization program was initiated at the Marine Sciences Laboratory (MSL), a part of the Pacific Northwest National Laboratory (PNNL) with the objective to evaluate advanced absorbent materials for the extraction of uranium using natural seawater. The uranium from seawater program is being conducted by the United States Department of Energy, Office of Nuclear Energy, Fuel Resources Program, in coordination with Oak Ridge National Laboratory (ORNL) for adsorbent synthesis and characterization, and Lawrence Berkeley National Laboratory for characterization of the thermodynamics and kinetics of adsorption. The MSL has a specialized ambient seawater delivery system for material testing and specialized analytical capabilities for determination of trace elements in natural seawater at part per trillion levels.
Marine testing of adsorbent fibers is being conducted in packed columns using flow-through filtered natural seawater in which temperature and flow-rate (linear velocity) are controlled at realistic marine conditions. Measurements of the adsorption of uranium and other elements from seawater as a function of time onto the adsorbent materials are used to determine the adsorbent capacity and adsorption rate (kinetics) of uranium and other elements. An adsorption capacity of 3240 μg U/ g adsorbent (normalized to a salinity of 35 psu) was observed with multiple time series experiments using the ORNL amidoxime-based polymeric adsorbent after 8 weeks of exposure in natural filtered seawater. Applying a one-site ligand saturation model predicts a saturation adsorption capacity of 4890 ± 830 μg U/g of adsorbent material (normalized to a salinity of 35 psu) and a half-saturation time of 28 ± 10 days. The amidoxime-based adsorbent material developed by the Japan Atomic Energy Agency was used a reference material in conducting these investigations. Additional adsorbent characterization studies have been initiated with high surface area nanomaterial adsorbents and to investigate the effects of flow-rate (linear velocity) and temperature on adsorption capacity and adsorption rate. Assessing the durability of adsorbent materials to marine conditions has focused on developing optimal chemical extraction pathways for removal of uranium from adsorbent material and understanding the impact of biological fouling on adsorbent capacity and kinetics for re-use.
Mining the sea for uranium at viable scales will require deployment of expansive "farms"of adsorbent material that must be shown not to harm marine biota and the marine ecosystem. This program has been investigating two issues: toxicity of adsorbent material and reduction in ocean currents from deployment of a farm of "kelp-like"adsorbent material. Toxicity testing is being conducted with the "Microtox®"aquatic toxicity test on solid adsorbents and column effluents containing adsorbent…
See attachment for full abstract.

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