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Pb^{2+} uptake by natural and synthetic zeolites, as a contribution to the sustainability of geothermal energy use

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Changes in the thermodynamic equilibrium of formation fluids in the heat extraction cycle of a geothermal power plant can result in gas and salt oversaturation and consequently in precipitation. Lead (Pb) is an element that is common in deep fluids and precipitates as lead sulfide or laurionite causing problems especially due to its content in radioactive ^{210}Pb isotope.

Natural clinoptilolite-Ca was tested for application to remove Pb^{2+} from geothermal fluids. Batch and dynamic flow-through experiments were performed at salinities I = 0.1 and 1 mol/l in NaCl or $CaCl_2$ solutions at up to 130 °C. The batch experiments resulted in an uptake of up to 24 % at an initial concentration of 0.3 g/l and up to 93 % at 0.03 g/l of Pb^{2+} and 115 °C. The presence of $CaCl_2$ in the solution matrix reduced the uptake of the heavy metals. The Pb^{2+} uptake at dynamic flow-through conditions at 130 °C was 52 % of the initial 20.7 mg/l during the 180 min experimental time. Based on the results the data fitting indicated a site density of monovalent exchange sites of 3.0 ± 2.6 mmol/g solid and a cation exchange capacity (CEC) of 295 ± 26 meq/100 g zeolite. The Pb^{2+} uptake process by zeolite gave a KD value of log K = 1.53. In a next step, clinoptilolite and chabazite were tested for their adsorption properties in natural and synthetic fluids of near natural composition. Under these conditions very low or no adsorption of Pb^{2+} was observed. Too achieve better results, six commercially available synthetic zeolites were pre-tested and three best performing materials were selected for further tests. The adsorbents have a homogeneous crystal structure and their specific surface area is almost 20 times greater compared to the natural clinoptilolite. Several test series were carried out at 70 and 115 °C, initial lead concentrations from 10 to 100 mg/l and adsorption times from 5 min to 7 days at a solid-liquid ratio of 0.7 g/l. Results showed that the lead uptake of synthetic zeolites in the specified concentration range reaches 50 to 75 % after just 5 minutes.