Title:

Contribution of Major Ions to Toxicity of Oil Shale Leachates to Aquatic Organisms

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Leachates of raw (i.e., unprocessed) and spent (i.e., processed) oil shale contain high concentrations of major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and anions (Cl^{-}, HCO_3^{-}, SO_4^{2-}) [e.g., >20,000 mg/L (300 mM) total major ions]. In the past, researchers have indirectly inferred large contributions of those major ions to the toxicity of raw and spent oil shale leachates to aquatic organisms, by comparison to results of toxicity tests with individual inorganic salts (e.g., NaCl, $MgSO_4$). However, no one has calculated the percentage contribution of the major-ion mixtures in oil shale leachates to observed toxicity. To address that deficiency, I used a published model of major-ion toxicity to predict the acute toxicity of major-ion mixtures in leachates from raw Tract C-a and Tract C-b oil shale and from spent Paraho oil shale to an aquatic invertebrate (*Daphnia magna*) and a fish (the fathead minnow, *Pimephales promelas*). In those leachates, the dominate cation was either Mg^{2+} or Na^{+}, and the dominant anion was SO_4^{2-}. In general, the unadjusted major-ion toxicity model over-predicted leachate toxicity, with predicted LC50s up to 7.7× less than observed LC50s. However, when between-study differences in toxicity of major salts were accounted for, the predicted LC50s were <3× less than observed LC50s. These results demonstrate that much, if not all the toxicity of oil shale leachates can be caused by major ions. Therefore, the potential contribution of major ions to the toxicity of oil shale leachates should not be overlooked.

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