

Secondary effects of hydrocarbon sources and waste materials in the environment: mobilization of arsenic and trace elements

ISABELLE MARY COZZARELLI¹, BRADY A. ZIEGLER²,
KATHERINE L JONES³, ZOE LACEY² AND MADELINE E
SCHREIBER⁴

¹USGS

²Trinity University

³University of Texas

⁴Virginia Tech

Presenting Author: icozzare@usgs.gov

The accidental release of petroleum products to aquifers with naturally occurring (geogenic) arsenic (As) can mobilize As to groundwater through biodegradation of the hydrocarbons coupled to reduction of ferric (Fe(III)) hydroxides. Accidental or intentional releases, recycling, and reuse of oil and gas wastes can also result in the mobilization of As into groundwater. We previously documented that, at a legacy crude-oil spill site, plumes of As could pose a greater longer-term water-quality threat than benzene. We recently assessed the spatial distribution of 35 elements in aquifer sediments and groundwater of a crude-oil-contaminated aquifer near Bemidji, MN. Hydrocarbon biodegradation coupled to Fe(III)-reduction appears to cause dissolution and mobilization of barium (Ba), strontium (Sr), cobalt (Co), and nickel (Ni) sorbed to ferric hydroxides. Trace element plumes occur in the crude-oil-contaminated portion of the aquifer, where 50% of Co, 47% of Ni, 24% of Ba, and 15% of Sr has been mobilized from sediment into groundwater, resulting in dissolved masses >33, 18, 3, and 2 times greater, respectively, than estimated dissolved masses prior to contamination. The plumes of Co, Ni, Ba and Sr do not extend as far downgradient as the As plume, indicating different attenuation reactions control their transport. Reactive transport modeling results show that the plumes of Co, Ni, Ba and Sr are limited by sorption to negatively charged carbonates in the Fe-reducing zone, whereas As oxyanion transport is attenuated further downgradient by sorption to positively charged ferric hydroxides. Barium and Ni concentrations exceeded the 700 µg/L WHO drinking water guideline and the 70 µg/L USEPA health advisory level, respectively. Representative concentrations from background wells, for comparison, were 87 µg/L for Ba and 1.31 µg/L for Ni. This slow but persistent biogeochemical activity can substantially alter aquifer chemistry over decadal timeframes and reduce supply of available safe drinking water.