

STUDY TITLE: Role of Bottom Sediment Redox-Chemistry Near Oil Production Facilities on Sequester/Release/ Degradation of Metals, Radionuclides and Organics

REPORT TITLE: Effect of Produced-Water Discharge on Bottom Sediment Chemistry

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APPLICABLE PLANNING AREA: Northern

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PROJECT MANAGER: R. D. DeLaune

AFFILIATION: Louisiana State University

ADDRESS: Wetland Biogeochemistry Institute, Center for Coastal, Energy, and Environmental Resources, Baton Rouge, Louisiana 70803

PRINCIPAL INVESTIGATORS*: R.D. DeLaune, C.W. Lindau, R.P. Gambrell

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BACKGROUND: Petroleum hydrocarbons, metals and radionuclides can enter the environment as the result of petroleum extraction and recovery operations. Produced water discharge associated with oil recovery has in the past introduced these compounds into Louisiana aquatic environment, including the sediment column. Investigations were conducted to determine the factors determining solubility and mobility of these pollutants in sediment. The overall objective of the study was to determine influence of sediment biogeochemistry near oil production facilities on sorption release and degradation of toxic organic, metals and radionuclide entering the sediment column.

OBJECTIVES: The objectives of the project were to study the sequester, adsorption/release, and degradation of toxic organics, metals and radionuclides of sediment in vicinity of oil production facilities.

DESCRIPTION: Laboratory and field studies were conducted for determining the factors affecting the available solubility of heavy metals and radium along with degradation of hydrocarbons in sediment. The effect of sediment redox conditions on speciation and solubility of metals was determined. Solubility of barium and radium in sediment collected from a produced water discharging site was measured. The influence sediment redox and pH on hydrocarbon degradation was also quantified.

SIGNIFICANT CONCLUSIONS: Heavy metal solubility was shown to be low in anaerobic and neutral pH estuarine sediment found at coastal Louisiana produced water discharge sites. Solubility of Ba found in barite was low under alkaline and either anaerobic or aerobic sediment conditions. Over 95% of radium found in contaminated sediment existed as an unavailable form which could be extracted only with strong acids. Typical heavy metal pollution levels found in surface sediment environment at produced water discharge sites would not impact microbial degradation of petroleum hydrocarbons in the sediment columns. Oxidized sediment conditions resulted in faster rate of petroleum hydrocarbon degradation as compared to reducing sediment conditions in a produced water impacted sediment column.

STUDY RESULTS: The effect of sediment redox conditions on the solubility of Fe, Pb, Ni, Ba, and Cu in bottom sediment collected from a produce water discharge site was investigated using kinetics and chemical fractionation procedures. Under oxidizing sediment conditions, the behavior of Fe, Pb and Ni were governed by Fe(III) and Mn(IV) oxides; Ba by insoluble complexation with humic compounds, Cu by carbonates and humic complexation. Under reducing sediment condition, the behaviors of Fe and Cu were controlled by the formation of insoluble sulfides, carbonates and humic complexes.

Kinetics and chemical fractionation procedures were also used in quantifying the effects of sediment redox (Eh) condition on the behaviors of As, Cd, Cr and Zn in the bottom sediment. Under oxidizing conditions, As, Zn and Cr behavior were governed by redox chemistry of Fe(III) and Mn(IV) oxides. Cd transformations were controlled by both Fe(III), Mn(IV) oxides and carbonates. Under reducing condition, the behaviors of Zn and Cr was controlled primarily by insoluble large molecular humic material and sulfides; the behavior of Cd was controlled by carbonates. When sediment redox potential increased, the affinity between Fe(III), Mn(IV) oxides and As, Cd, Cr, and Zn increased. Results suggest reducing conditions in bottom sediment sites of produced water discharge would limit heavy metal availability.

Sediment collected from a produced water discharge site and in waste pit was extracted into various chemical fractions and analyzed for radium-226 (fractions included water-soluble, exchangeable, forms associated with carbonates, reducible, or organic/sulfide). It was determined that 95 percent of the radium present was tied up in an unavailable form that could be extracted only with very strong acids. Radium in this fraction would be released very slowly into the environment. Results showed that less than 5% of the radium in sediment was in potentially available forms.

Petroleum hydrocarbon degradation was measured in sediment collected from a low energy brackish wetland site which had been exposed for a number of years to produced water discharge was also studied. Recalcitrant or higher molecular weight compounds were the primary hydrocarbon fractions found in the sediment. Degradation rates were determined by measuring loss of selected petroleum hydrocarbons components with time in laboratory incubation. South Louisiana Crude oil was added to the sediment to measure degradation rates of soluble hydrocarbons which were too low in concentration in the original sediment. Oxidized sediment conditions resulted in a higher rate of degradation for most hydrocarbons fractions as compared to degradation in reduced sediment. Nutrient amendments to contaminated sediments significantly increased rate of hydrocarbon degradation.

The effect of chromium (Cr) and lead (Pb) on degradation of South Louisiana Crude oil in sediment collected from a produced water discharge site was also measured under both reducing and oxidized conditions. Results showed that metal concentration normally found at produced water discharge sites would not influence degradation of hydrocarbon in the sediment profile.

STUDY PRODUCT: Louisiana State University, Wetland Biogeochemistry Institute 1999 Effect of Produced-Water Discharge on Bottom Sediment Chemistry. A final report for the U.S. Department of the Interior, Mineral Management Service Gulf of Mexico OCS Region, Metairie, LA. OCS Study MMS 99-0060. Contract No. 14-35-0001-30660-19907.

*P.I.'s affiliation may be different than that for Project Manager(s).