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Title: Mobility and Transport of Radium from Sediment and Waste Pits
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Objectives/Hypothesis
The objective of the research was to determine the factors controlling the transport and movement of radium in the sediment environment, focusing specifically on the geochemistry of radium in coastal sediments and waste pits contaminated during oil production operations. The main focus of the study was to determine the effect of sediment redox/pH conditions on radium geochemistry, attenuation and movement. Processes of interest include precipitation and complexation.

Approach
Experiments were conducted to determine the factors affecting the solubility and mobility of ^{226}Ra in sediments contaminated by produced water discharges. Bottom sediments and waste pit material with high ^{226}Ra activities were collected and incubated in microcosms under controlled conditions. Additional experiments were conducted to determine ^{226}Ra flux from these sediments.

Results
Results indicate that ^{226}Ra solubility is controlled by co-precipitation of radium within sulfate minerals (e.g. barite and gypsum). Very little radium is in available or potentially available forms. Fluxes of radium from waste pit material are very low (of the same order of magnitude as natural "uncontaminated" systems). In biologically-active, contaminated bottom sediments, conversion of sulfate to sulfide results in the dissolution of some barite releasing small amounts of radium to other available forms. Fluxes of radium from these bottom sediments were up to an order-of-magnitude greater than in waste pits and natural, uncontaminated systems.

Key results include: 1) selective extractions of sediment and waste material indicated that very low activities of radium are present in "available" or "potentially available" forms. Nearly all of the radium activity (>>95%) can only be extracted using strong acids; 2) the modified MINTEQ geochemical speciation model indicated that sediment and waste pit porewater is unsaturated with respect to pure radium materials but supersaturated with respect to other sulfate minerals such as barite ($BaSO_4$) and gypsum ($CaSO_4$ $2H_2O$). Radium can precipitate within these minerals. 3) calculations indicate that radium activities present in these sediments can easily be accounted for by co-precipitation in small amounts of these sulfate minerals; 4) in the biologically-active bottom sediments under anaerobic conditions, conversion of sulfite to sulfide results in the dissolution of some barite, redistributing small amounts of radium (approximately 5% of the total activity) to available and potentially available forms. 5) little or no additional effect was

determined for Eh-pH on radium solubility, despite very low pH's (2.8-4.0) when waste pit and sediment were oxidized; and 6) despite the high activities present in the waste pit material, fluxes of ^{226}Ra were of the order of magnitude as in natural "uncontaminated" systems. Fluxes from the bottom sediment were an order of magnitude higher.

Summary of Results

- Analysis of waste pit materials indicates that "availability" of radium is generally low
- Radium activities are consistent with co-precipitation with barite and gypsum
- Anaerobic conditions in the waste_pit can result in mobilization of ~5% of radium
- Radium availability does not depend upon Eh_pH in the waste pits and sediments analyzed.

Supplemental Keywords

Geochemistry, fate and transport, and solubility

Students Supported

T.Z. Guo, M.S., 1998

Publications and Presentations

- DeLaune, R., J. Pardue, W. Patrick, Jr., and C Lindau, "Mobility and Transport of Radium in Sediment and Waste Pits", Final Project Report submitted to the South and Southwest Hazardous Substance Research Center, March 1996.
- Pardue, J. and A. Jackson, "Natural Attenuation of Toxic Organic Compounds in Wetland Environments", WERC/HSRC Joint Conference on the Environment, Albuquerque, NM, April,
- Pardue, J. and T. Guo, "Biogeochemistry of Radium-226 in Contaminated Bottom Sediments and Oilfield Waste Pits", submitted to *Journal of Environmental Radioactivity*.
- Pardue, J., "An Explanation for the Formation of Radioactive "Hot Spots" in Sediments near Produced Water Discharges", submitted to *Health Physics*.
- Research Brief #2: Mobility and Transport of Radium in Sediment and Waste Pits (1993).

For Further Information

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