The Distribution and History of Nuclear Weapons Related Contamination in Sediments from the Ob River, Siberia as Determined by Isotopic Ratios of Plutonium, Neptunium, and Cesium

by

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Abstract

This thesis addresses the sources and transport of nuclear weapons related contamination in the Ob River region, Siberia. In addition to being one of the largest rivers flowing into the Arctic Ocean, the bulk of the former Soviet Union's nuclear fuel reprocessing and weapons testing facilities (i.e. Mayak, Tomsk-7, and Semipalitinsk) are located within the Ob drainage basin. The atom ratios $^{240}Pu/^{239}Pu$, $^{237}Np/^{239}Pu$, and $^{137}Cs/^{240}Pu$, measured by magnetic-sector ICP-MS, are used to distinguish between contamination derived from global fallout and contamination derived from local sources. Deposition chronologies estimated for sediment cores are used to construct a record of weapons related contamination at the sites sampled. Contaminant records indicate that in addition to debris from atmospheric weapons tests, materials derived from local sources have also played a role in nuclear weapons related contamination of the Ob region. Isotopic data presented in this study clearly demonstrate that non-fallout contamination has been transported the full length of the Tobol, Irtysh, and Ob Rivers (i.e. the tributaries draining Mayak, Semipalitinsk, and Tomsk-7, respectively).

In several instances, unique isotopic compositions are observed in sediments collected from tributaries draining each of the suspected non-fallout sources. In such cases, these materials and their deposition ages have been used to link contamination in the Ob delta to Mayak, Tomsk-7, or Semipalitinsk. Linear transport rate estimates (km yr^{-1}) indicate that contaminated sediments transit between source tributaries and the Ob delta on time-scales of $\leq$ 1year. These estimates suggest that a catastrophic release of contamination due to dam failure at one of the many reservoirs located at both Mayak and Tomsk-7 that contain high levels of radioactive waste would result in measurable levels of contamination in the delta within as little as 1 year.

Isotopic concentrations in sequentially extracted sediments containing weapons related contamination reveal that the majority of plutonium and neptunium (80 to 90 percent) behaves in a similar fashion regardless of the source and is removed by treating the sediments with citrate-dithionite. This indicates that plutonium and neptunium are not truly refractory and likely associate with redox sensitive sedimentary components. Isotopic ratios measured in extracted fractions suggest that only a minor fraction of contamination is associated with acid leachable or acid digestible sedimentary phases.

Thesis Supervisor: Frederick L. Sayles, Scientist Emeritus

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