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Federal Contaminated Sites Action Plan (FCSAP)

**FCSAP Advisory Bulletin (FAB):
Radionuclides in Groundwater**

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Radionuclides in Groundwater

Background

A nuclide is an alternative name for an atom whose nuclei have specific numbers of protons and neutrons (both are called nucleons). Nuclides are composite particles of nucleons (Chieh, 2003). A radionuclide is an unstable form of a nuclide that undergoes radioactive decay. Radionuclides may occur naturally in groundwater through contact with rocks or soils that have Naturally Occurring Radioactive Materials (NORM), but can also be the resultant of anthropogenic activities. Most background groundwaters have very low levels of naturally occurring radionuclides (e.g. uranium 238, thorium 232, potassium 40, lead 210 and radium 226) (United States Environmental Protection Agency (USEPA), 1992). Naturally occurring radionuclides can be concentrated in groundwater through the following activities;

- Wastes generated during metal mining and processing operations – aluminum, uranium, copper, rare earths, precious metals;
- Wastes generated from fertilizers and the production of fertilizers;
- Landfills;
- Oil and gas production;
- Waste water treatment wastes; and
- Waste water from land-based storage/decontamination of contaminated sediment.

Groundwater can also be impacted from anthropogenic sources of radionuclides through activities such as nuclear testing or power generation and associated wastes (eg. uranium 235, tritium, cesium 137, strontium 90, and plutonium 244).

Radionuclides are generally predicted to have very slow travel times in groundwater. This is not a result of their radioactivity but a function of their low solubility (Nitsche et al, 1993) and strong sorption (Triay et al, 1996) but transport in groundwater through colloid-facilitated transport is commonly seen at testing facilities where underground waste storage is recommended (Kersting et al, 1999). Colloid-facilitated transport generally refers to contaminants of concern adsorbed on dissolved organic matter or soil particles such as clays that have a high cation exchange capacity. Radionuclides can also form their own colloids. Colloid-facilitated transport of radionuclides is a concern in groundwater and risk assessments due to pore exclusion of colloidal particles which can result in transport of radionuclides in groundwater at a rate that is greater than the average groundwater velocity (Degeuldre, 1997).

Standard Approach

At contaminated sites where radionuclides are a concern (or potential concern, i.e. those types of contaminated sites listed in the previous section), it is important that groundwater sampling protocols be in place to investigate the potential for colloid-facilitated transport (Backhus et al, 1993), in addition to standard sampling protocols for radionuclides (Canadian Council of Ministers of the Environment (CCME), 2011a). Radionuclides in groundwater can be initially investigated using inductively coupled

plasma-mass spectrometry (ICPMS) to screen samples for radionuclide contamination. Those contaminants of potential concern analyzed with an ICPMS are uranium, thorium, and radium (International Atomic Energy Agency (IAEA), 2010). The main advantages to using this method are high sensitivity and short analytical times, requiring only a few minutes (IAEA, 2010).

Guidelines for radionuclides in groundwater for the protection of human health have been developed by Health Canada (Health Canada, 2009). CCME has developed guidelines on chemical toxicity for Uranium in water for the protection of aquatic life, not toxicity from radioactivity (CCME 2011b). For other guidelines or standards that may be applicable for your site, please refer to the Database of Guidelines (DOG), developed by Environment and Climate Change Canada.

Disclaimer

FCSAP Expert Support provides the above information in accordance with the FCSAP and associated guidelines and policies including our mandate under the Fisheries Act subsection 36(3). This is in no way to be interpreted as any type of approval, authorization, or release from requirements to comply with federal statutes and regulations. If you have any questions or concerns, please e-mail: fcsap.pascf@ec.gc.ca, or contact your regional FCSAP Expert Support.

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Suggested Further Reading

Database of Guidelines (DOG), 2014. A compilation of environmental quality guidelines and benchmark values for chemicals in various media from multiple national and international jurisdictions to facilitate screening and remediation processes for federal contaminated sites. The DoG should be used as a reference only. The primary documentation should always be consulted before the application of a guideline, to ensure that its use is appropriate and scientifically defensible. The DoG is considered up to date as of December 31st, 2012 and is not guaranteed to have the most recent guidelines.

Additional information can be obtained at:

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