Rate of migration of a tritium plume in groundwater with ^{3}He

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Tritium (T) is present in the environment at background levels from natural production via cosmic radiation in the atmosphere, and as a by-product of nuclear reactor facilities and nuclear weapons testing. Large quantities of tritium are produced in Canada due to the use of deuterium oxide (D_2O or heavy water) as a moderator in CanDU nuclear reactors. Significant quantities of tritium are generated through neutron activation of heavy water. Tritium gas (T_2) obtained from associated tritium removal facilities is used as a radiation source in T_2 filled tubes (Betalights™) used for electricity-free illumination. Elevated tritium concentrations in the environment are a concern to human health due to the radioactive properties of the isotope, with a half life of 12.32 years. The research area of this tritium plume study is located on the property of the SRB Technologies Betalight™ facility in Pembroke, ON, where tritium has infiltrated the underlying groundwater. 2 of the 20 analyzed monitoring wells on the property showed tritium concentrations in excess of drinking water standards (above 7000Bq/L) in 2016. The maximum tritium concentration is located at the gas emitting stacks, with concentrations ranging from 157 000Bq/L in 2006 to 53 311Bq/L in November, 2016. The purpose of this research is to use ^{3}He gas, ingrown as the daughter of the tritium decay reaction, as a tool to quantify the rate of migration of the tritium plume and to predict its potential time of impact on local surface waters. Gas collecting diffusion samplers were installed at the bottom of twenty groundwater monitoring wells located in the contamination plume. Gas samples were analyzed using the University of Ottawa Helix Split Flight Tube Noble Gas Mass Spectrometer for tritiogenic ^{3}He. Results display elevated ^{3}He levels above background conditions that correlate to recent groundwater tritium concentrations. Maximum tritiogenic ^{3}He levels from the most tritium rich monitoring well reached 6043 times the air standard of $^{3}He/^{4}He$. Groundwater flow rates are determined from the measured tritiogenic ^{3}He concentration to determine the rate of movement of the tritium contamination plume. The results are compared with previously obtained tritium concentrations to model the tritium plume activity over time.