



## Halon-1301, a new Groundwater Age Tracer

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Groundwater dating is an important tool to assess groundwater resources in regards to direction and time scale of groundwater flow and recharge and to assess contamination risks and manage remediation. To infer groundwater age information, a combination of different environmental tracers, such as tritium and SF<sub>6</sub>, are commonly used. However ambiguous age interpretations are often faced, due to a limited set of available tracers and limitations of each tracer method when applied alone. There is a need for additional, complementary groundwater age tracers.

We recently discovered that Halon-1301, a water soluble and entirely anthropogenic gaseous substance, may be a promising candidate [Beyer et al, 2014]. Halon-1301 can be determined along with SF<sub>6</sub>, SF<sub>5</sub>CF<sub>3</sub> and CFC-12 in groundwater using a gas chromatography setup with attached electron capture detector developed by Busenberg and Plummer [2008]. Halon-1301 has not been assessed in groundwater.

This study assesses the behaviour of Halon-1301 in water and its suitability as a groundwater age tracer. We determined Halon-1301 in 17 groundwater and various modern (river) waters sites located in 3 different groundwater systems in the Wellington Region, New Zealand. These waters have been previously dated with tritium, CFC-12, CFC-11 and SF<sub>6</sub> with mean residence times ranging from 0.5 to over 100 years. The waters range from oxic to anoxic and some show evidence of CFC contamination or degradation. This allows us to assess the different properties affecting the suitability of Halon-1301 as groundwater age tracer, such as its conservativeness in water and local contamination potential.

The samples are analysed for Halon-1301 and SF<sub>6</sub> simultaneously, which allows identification of issues commonly faced when using gaseous tracers such as contamination with modern air during sampling.

Overall we found in the assessed groundwater samples Halon-1301 is a feasible new groundwater tracer. No sample indicated significantly elevated concentration of Halon-1301, which indicates absence of local anthropogenic or geologic sources (contamination), despite some samples showing CFC contamination. We found agreement of 71% of mean age estimates with ages inferred from tritium and SF<sub>6</sub> within +/- 2 years, for samples where direct age comparison could be made. The remaining sites showed reduced concentrations of Halon-1301 along with reduced concentrations of CFCs. The reasons for this need to be further assessed, but are likely caused by sorption or degradation of Halon-1301.

Further Halon-1301 studies are planned covering various hydrogeologic situations, land use practises, and redox conditions to evaluate the potential of Halon-1301 as groundwater tracer, and to elucidate the causes for reduced Halon-1301 concentrations.

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### References

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