University of Nebraska Lincoln

School of Natural Resources
Water Sciences Laboratory

Removal Efficiency Test – Water Distillation for Cesium

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Cesium is a rare but naturally-occurring element in the earth's crust. Although there are almost 40 known isotopes of this element, the most commonly are Cs-133, Cs-134, Cs-135, and Cs-137. The stable (nonradioactive) form of this element (Cs-133) is used in drilling fluids, electricity generation, and electronics manufacturing. The most common radioactive isotope, cesium-137, is a beta emitter with a half-life of about 30 years and is used in medical applications, industrial gauges, and as a tracer in hydrology. Chemically, the element is only mildly toxic, though its radioactive isotopes may present a health risk in case of radiation leaks. In particular, Cs-137 is one of the two most commonly fission products responsible for the long-lived radioactivity of spent nuclear fuel. It also is one of the radioactive isotopes monitored in spills from nuclear reactors. Because the chemical properties of the isotopes of an element are essentially identical, it is useful to conduct tests using the non-radioactive isotopes to make predictions about removal processes for the radioactive forms.

A Steampure PD table top water distillation (Pure and Secure, LLC, Lincoln, NE) unit was provided by the manufacturer and tested for removal of dissolved cesium from fortified tap water. The unit was tested after developing and validating a method for Cs-133 analysis using inductively coupled plasma mass spectrometry (ICP-MS). Cesium instrument detection limits, determined by measurement of the variability of a low level standard, were near 0.2 ug/L (ppb). After operating the distillation unit for 1-day (distilling approximately 4 liters of unmodified tap water) the unit was drained and refilled. Tap water collected before spiking indicates that the concentration in the unmodified tap water was near the detection limit (0.3 ppb). Tap water was fortified by adding 1-millititer of cesium stock solution (SPEX Certiprep, 1000 ug/mL) directly to the boiling tank and the contents mixed. The concentration in the fortified tap water was near 180 ppb. The unit was then operated for 6 hours, and during distillation, 3 separate samples of distilled water collected from the glass storage reservoir. .

The results of the analysis (Table 1) indicate cesium concentrations were near or below the detection limits in all three samples. The average of 3 replicates indicates a cesium reduction of 99.8% based on the challenge level of 180 ppb. A second test was conducted to confirm the first and to measure the effect of the effect of acid used as a preservative in the cesium stock solution. . Tap water pH was measured before and after adding the cesium standard (7.2) and appeared to be unaffected by the small amount of nitric acid introduced in the cesium standard. Both tests indicate >99% reduction of cesium from the challenge concentration in the fortified tap water.

Sample_ID	Collection_Date	Cesium
TAP WATER 060911	6/8/2011	0.3
TAP SPIKED 100 PPB 060911	6/9/2011	178.9
TREATED SPIKED 060911-1	6/10/2011	0.6
TREATED SPIKED 060911-2	6/10/2011	0.3
TREATED SPIKED 060911-3	6/10/2011	<0.2
Average		**0.4**
06092011 Percent Reduction		**99.8%**

Sample_ID	Collection_Date	Cesium
TAP WATER 061011	6/10/2011	0.1
TAP SPIKED 100 PPB 061011	6/10/2011	181.1
TREATED SPIKED 061011-1	6/10/2011	0.5
TREATED SPIKED 061011-2	6/10/2011	0.3
TREATED SPIKED 061011-3	6/10/2011	<0.2
Average		**0.4**
06102011 Percent Reduction		**99.8%**

Table 1. Results from 2 separate tests of cesium removal efficiency by distillation of water.

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