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Uranium Concentrations in Asparagus

B. L. Tiller
T. M. Poston

May 1992

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
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SUMMARY

Concentrations of uranium were determined in asparagus collected from eight locations near and ten locations on the Hanford Site southcentral Washington State. Only one location (Sagemoor) had samples with elevated concentrations. The presence of elevated uranium in asparagus at Sagemoor may be explained by the elevated levels in irrigation water. These levels of uranium are comparable to levels previously reported upstream and downstream of the 300-FF-1 Operable Unit on the Hanford Site ($0.008 \mu\text{g/g}$), but were below the $0.020\text{-}\mu\text{g/g}$ level reported for brush collected at Sagemoor in a 1982 study. Concentrations at all other onsite and offsite sample locations were considerably lower than concentrations reported immediately upstream and downstream of the 300-FF-1 Operable Unit. Using an earlier analysis of the uranium concentrations in asparagus collected from the operable unit, the dose to consumers of asparagus collected from the Hanford Site constitutes a very small fraction of the U.S. Department of Energy effective dose equivalent limit of 100 mrem.

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INTRODUCTION

Asparagus is an edible, introduced plant that grows wild on the Hanford Site in southcentral Washington State. It is most commonly found at locations along the Columbia River and in old agricultural areas abandoned when the Site was established in the 1940s. Some of these areas are accessible to the public, and harvesting of asparagus does occur.

Brandt^(a) sampled asparagus to assess the need for future vegetation sampling at the 300-FF-1 Operable Unit and to obtain information regarding levels of contaminants in plant species that compose part of the human food chain. He found that asparagus growing within the operable unit contained approximately three times the level of total uranium (0.026 $\mu\text{g/g}$ dry weight) compared to those samples taken from upstream and downstream (0.008 $\mu\text{g/g}$ dry weight) of the operable unit. He also found that uranium concentrations in asparagus were directly correlated with the groundwater uranium distribution in and around the operable unit.

Soldat^(b) estimated doses to determine the relative risk to a potential consumer of asparagus taken from the operable unit. The potential 50-year committed effective dose equivalent (EDE) from consuming 10 kg of that asparagus was 0.05 mrem. This dose was a very small fraction of the U.S. Department of Energy EDE limit of 100 mrem and therefore did not constitute a significant hazard.

In response to these findings, we collected asparagus in 1990 at several areas on and off the Hanford Site to better characterize the distribution of uranium in asparagus (Figure 1). Commercially grown asparagus was collected from farms located around the Hanford Site. Of the sampling locations, Sunnyside, Toppenish, Mattawa, and Moses Lake are located upwind from Hanford (Figure 2) and represent areas generally uninfluenced by Hanford operations. Wahluke, Sagemoor, and Walla Walla are generally downwind from the Hanford

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- (a) Brandt, C. 1989. Asparagus Analysis Results - Letter Report. A letter report to P. Long, Pacific Northwest Laboratory, Richland, Washington.
- (b) Soldat, J. K. 1989. Calculation of Potential Radiation Dose from Eating Asparagus Harvested Near the 300 Area. A letter report to R. K. Stewart, U.S. Department of Energy, Richland, Washington.

Site and are potential recipients of atmospheric deposition from Hanford. Samples collected onsite were grouped together for evaluation. The samples were analyzed for ^{234}U , ^{235}U , and ^{238}U .

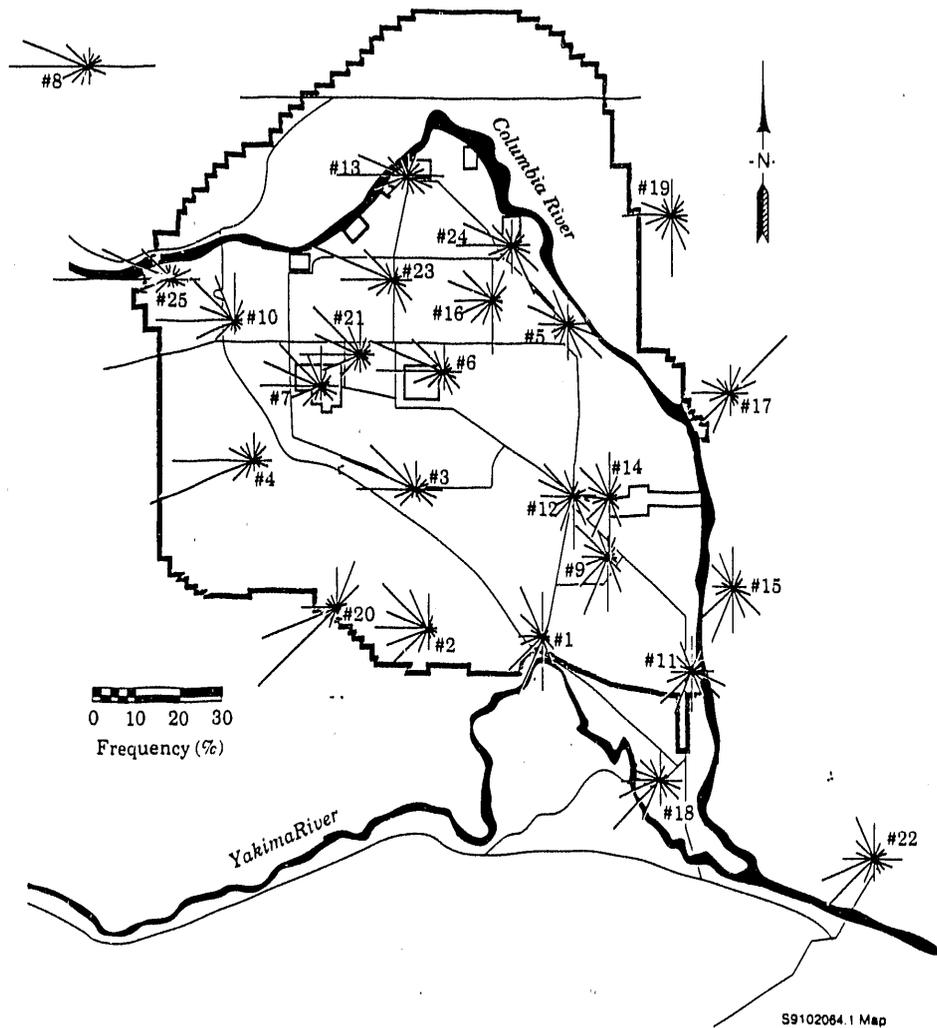


FIGURE 2. Hanford Telemetry Network Wind Roses, 1990^(a)

(a) Wind rose arrows indicate direction from which wind blows. Length of arrow is proportional to frequency of occurrence from a particular direction.

METHODS

SAMPLE COLLECTION AND PREPARATION

Onsite samples were collected by cutting about 500 g of asparagus at each location. Asparagus from offsite locations was sampled from three boxes of asparagus that had been cut from three different areas of the sample field. Asparagus samples were placed in paper bags, labeled, and delivered to the analytical laboratory.

ANALYTICAL METHODS

Asparagus samples were washed with tap water to remove dirt and debris. They were dried at 105°C, ground into a powder with a Wiley mill, homogenized, and stored in plastic bottles until analysis. A 5-g aliquot of each sample was amended with the internal standard of ^{232}U and ashed in a muffle furnace. The ash was digested in nitric acid, dried, and redissolved in hydrochloric acid. The hydrochloric acid preparation was passed through an anion exchange resin to remove the uranium. Uranium was eluted with water, dried, redissolved in hydrochloric acid, and extracted with diethyl ether to remove iron. The extracted uranium was then electrodeposited onto a stainless steel planchet for alpha spectroscopy. The minimum detection limit for ^{238}U was 0.001 pCi/g dry weight.

DATA ANALYSIS

Uranium-238 was used to indicate the relative concentrations of uranium. The ^{235}U values for most samples were below the overall counting error and cannot be statistically evaluated. Activity ratios of ^{234}U to ^{238}U were examined to determine if there were any aberrations in the isotopic distribution. To compare our data with data from Brandt (1989), the total activity (pCi/g) for each uranium isotope was summed and multiplied by the conversion factor of 1.453 $\mu\text{g/pCi}$ uranium. Less-than values were included in the calculation.

RESULTS AND DISCUSSION

We used median uranium concentrations and the associated ranges for the sample groups to compare the results (Table 1). Mean values were not used to compare onsite and offsite uranium concentrations because such use can distort the interpretation of the results in favor of an uncharacteristically high or low value. The raw data are summarized in the appendix.

The median concentrations of ^{238}U range from $2.74\text{E-}04$ pCi/g at Toppenish to $2.01\text{E-}03$ pCi/g at Sagemoor (Figure 3). The third lowest median value ($3.3\text{E-}04$ pCi/g) comes from samples collected on the Hanford Site and is very similar to all sample group medians except those of the Sagemoor area. The Sagemoor data indicate a separate and distinct grouping. The three Sagemoor samples were the highest values of all samples collected (Figure 4).

A growing body of data shows that the higher concentrations of uranium in Sagemoor asparagus result from naturally high levels of uranium in the area. Price and Kinnison (1982) identified the Sagemoor area as having elevated uranium concentrations in the soil. However, they concluded that the elevated levels did not appear to be the result of Hanford operations; there was no significant difference (in the isotopic composition of uranium) between

TABLE 1. Uranium-238 in Asparagus Samples from in and Around the Hanford Site (pCi/g dry weight)

<u>Sample Location</u> ^(a)	<u>Mean + SD</u> ^(b)	<u>Median</u>	<u>Range</u>
Walla Walla (3)	$4.77\text{E-}04 \pm 1.33\text{E-}04$	$5.37\text{E-}04$	$3.24\text{E-}04$ to $5.69\text{E-}04$
Sagemoor (3)	$1.96\text{E-}03 \pm 2.88\text{E-}04$	$2.01\text{E-}03$	$1.65\text{E-}03$ to $2.22\text{E-}03$
Toppenish (3)	$2.58\text{E-}04 \pm 1.15\text{E-}04$	$2.74\text{E-}04$	$<1.35\text{E-}04$ to $3.64\text{E-}04$
Sunnyside (3)	$4.23\text{E-}04 \pm 9.70\text{E-}05$	$4.57\text{E-}04$	$3.14\text{E-}04$ to $4.99\text{E-}04$
Moses Lake (3)	$3.40\text{E-}04 \pm 1.46\text{E-}04$	$2.90\text{E-}04$	$2.26\text{E-}04$ to $5.05\text{E-}04$
Hanford Site (10)	$4.13\text{E-}04 \pm 2.62\text{E-}04$	$3.33\text{E-}04$	$<1.15\text{E-}04$ to $8.59\text{E-}04$
Mattawa (3)	$4.17\text{E-}04 \pm 1.78\text{E-}04$	$5.14\text{E-}04$	$2.12\text{E-}04$ to $5.25\text{E-}04$
Wahluke Area (6)	$5.18\text{E-}04 \pm 1.56\text{E-}04$	$4.88\text{E-}04$	$3.46\text{E-}04$ to $7.82\text{E-}04$

(a) The number of sample results is given within parenthesis.

(b) Mean and standard deviation (SD) were calculated with less-than-detection values as the sample value.

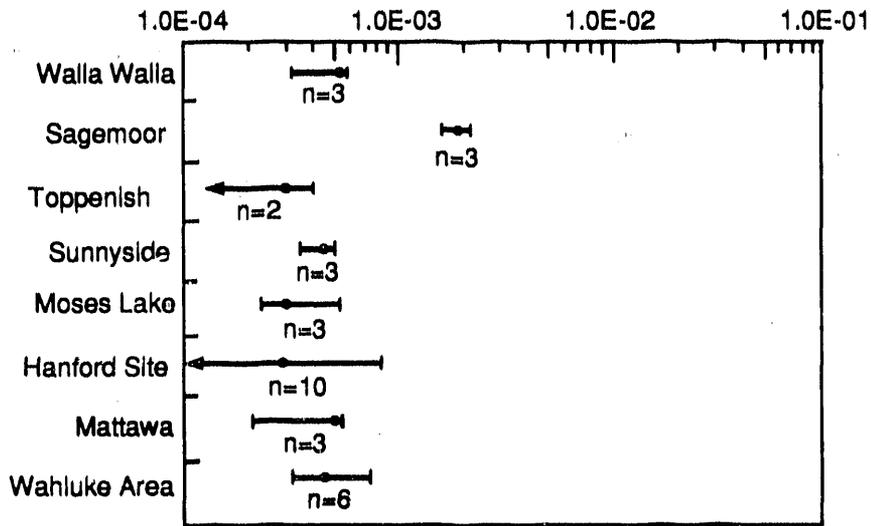


FIGURE 3. Asparagus Median Uranium-238 Values with Ranges (pCi/g dry weight)

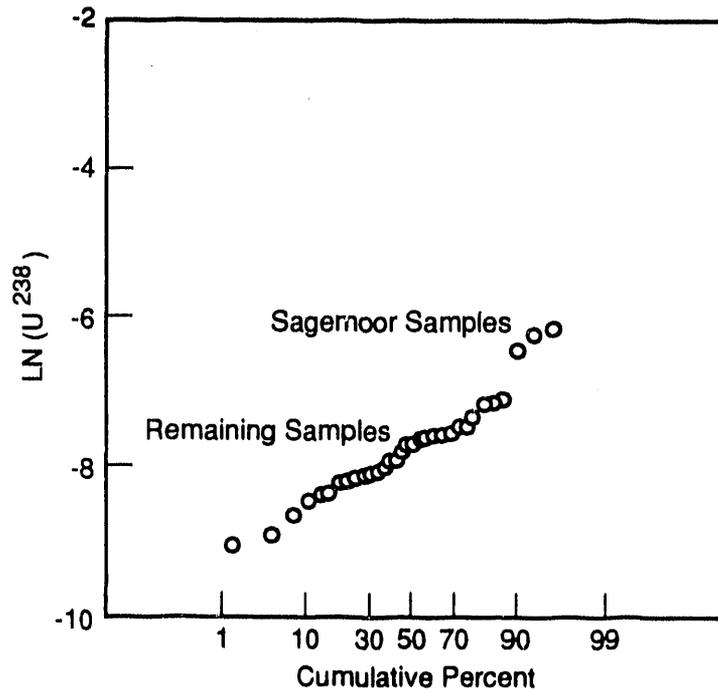


FIGURE 4. Normal Probability Plot for the LN Concentration (Uranium-238)

the Sagemoor area and their control site located downstream at Riverside. However, our asparagus sampling locations and those used for Price and Kinnison's (1982) study may differ.

Recently, elevated concentrations of uranium have been reported in soil, groundwater, and irrigation water in the Sagemoor area. The Washington Department of Social and Health Services (1988) reported concentrations as high as 26 and 31 pCi/L in wells drawing water from shallow aquifers in the Sagemoor area. These measurements were later confirmed by Jaquish (1989). Other wells permeating deeper aquifers (>200 ft) had less than detectable levels of uranium. Irrigation water and seepage into the Columbia River at Sagemoor also contained levels of uranium exceeding those in Columbia River water by a factor of 10 (Dirkes 1990). The irrigation water at Ringold and Byers Landing contained 2.3 pCi ²³⁸U/L. Sagemoor seepage water into the Columbia River was 3.9 pCi ²³⁸U/L. Background levels of uranium in the Columbia River were 0.17 + 0.02 pCi ²³⁸U/L.

Another indication that the elevated concentrations of uranium at Sagemoor are natural is that there is no ²³⁶U present in the well water samples containing elevated uranium (Jaquish 1989). Uranium-236 is formed by neutron activation of ²³⁵U and is not found as a natural isotope of natural uranium. Uranium-236 is present in soil samples immediately north of the 300 Area (Poston 1990) and in well and seepage water adjacent to the 300 Area on the Columbia River's west shoreline. Its presence results from the handling of irradiated fuel during research projects in the 300 Area (Jaquish 1989).

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APPENDIX

1990 ASPARAGUS SAMPLING

TABLE A.1. 1990 Asparagus Sampling Results

LOCATION	234Ja		235Ja		238Ja	
	Result	Overall Error	Result	Overall Error	Result	Overall Error
East of 100-D	4.53E-04	3.36E-04	2.52E-04	2.26E-04	6.54E-04	3.67E-04
	4.64E-05 ^b	1.61E-04	1.86E-04 ^b	1.86E-04	2.32E-04	2.09E-04
Hanford Townsite	6.89E-04	3.87E-04	1.59E-04 ^b	1.84E-04	2.65E-04	2.38E-04
	4.12E-04	2.63E-04	8.24E-05 ^b	1.17E-04	3.71E-04	2.75E-04
	5.63E-04	3.39E-04	1.30E-04 ^b	1.50E-04	3.03E-04	2.31E-04
	4.53E-04	3.16E-04	1.36E-04 ^b	2.03E-04	3.63E-04	2.58E-04
100-F Turn off	6.75E-04	3.94E-04	1.12E-04 ^b	1.59E-04	1.69E-04 ^b	1.95E-04
South of 100-F	3.84E-04	2.45E-04	7.69E-05 ^b	1.09E-04	1.15E-04 ^b	2.04E-04
South of 300-FF-1	1.00E-03	4.18E-04	7.11E-04	3.50E-04	7.94E-04	3.71E-04
Horn Rapids Rd/ Stevens Rd	5.46E-04	2.96E-04	2.34E-04	1.92E-04	8.59E-04	4.05E-04
OFFSITE FARM						
Mattawa	5.25E-04	3.06E-04	1.75E-04 ^b	2.15E-04	5.25E-04	3.06E-04
	6.08E-04	3.41E-04	4.68E-05 ^b	1.62E-04	5.14E-04	3.13E-04
	4.25E-04	2.96E-04	4.25E-05 ^b	8.50E-05	2.12E-04	1.91E-04
Moses Lake	1.26E-03	7.00E-04	1.89E-04 ^b	2.19E-04	5.05E-04	3.60E-04
	5.65E-04	4.08E-04	1.88E-04	1.69E-04	2.26E-04	1.85E-04
	4.98E-04	2.90E-04	2.07E-04 ^b	2.49E-04	2.90E-04	2.21E-04
Sunnyside	7.90E-04	3.69E-04	3.33E-04	2.37E-04	4.99E-04	2.91E-04
	4.48E-04 ^b	6.35E-04	2.69E-04	2.55E-04	3.14E-04	2.39E-04
	4.93E-04	2.85E-04	0.00 E00 ^b	1.06E-04	4.57E-04	2.57E-04
Toppenish	6.82E-04	3.97E-04	1.82E-04 ^b	1.82E-04	3.64E-04	2.89E-04
	1.80E-04	5.98E-04	2.70E-04	2.56E-04	1.35E-04 ^b	1.56E-04
	3.14E-04	4.16E-04	1.57E-04 ^b	1.92E-04	2.74E-04	3.26E-04

TABLE A.1. 1990 Asparagus Sampling Results (Cont)

LOCATION	234 _{Ua}		235 _{Ua}		238 _{Ua}	
	Result	Overall Error	Result	Overall Error	Result	Overall Error
	OFFSITE FARM					
Wahiuke Area	6.92E-04	3.75E-04	9.89E-05 ^b	1.40E-04	3.46E-04	3.29E-04
	6.33E-04	3.12E-04	1.86E-04 ^b	2.24E-04	7.82E-04	3.48E-04
	6.34E-04	3.22E-04	1.19E-04 ^b	1.78E-04	5.95E-04	3.11E-04
Wahiuke Slope	7.31E-04	5.52E-04	1.83E-04 ^b	1.83E-04	4.11E-04	2.76E-04
	4.48E-04	2.73E-04	1.63E-04	1.63E-04	5.29E-04	3.39E-04
	5.96E-04	3.02E-04	1.12E-04 ^b	1.67E-04	4.47E-04	2.61E-04
Waila Walla	4.99E-04	3.00E-04	1.15E-04 ^b	1.72E-04	5.37E-04	3.10E-04
	6.51E-04	3.50E-04	3.66E-04	2.46E-04	5.69E-04	3.08E-04
	5.40E-04	3.45E-04	1.62E-04 ^b	1.88E-04	3.24E-04	2.66E-04
Sagemoor	2.24E-03	6.44E-04	8.46E-05 ^b	1.69E-04	1.65E-03	5.46E-04
	2.13E-03	6.35E-04	2.93E-04	2.23E-04	2.01E-03	6.04E-04
	3.03E-03	7.94E-04	3.62E-04	2.88E-04	2.22E-03	6.60E-04

a Units in pCi/g dry weight
b Denotes values less than 2 sigma error

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