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A Comparison of Hanford and Savannah River Site High-Level Wastes

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-08RV14800

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ABSTRACT

This study is a simple comparison of high-level waste from plutonium production stored in tanks at the Hanford and Savannah River sites. Savannah River principally used the PUREX process for plutonium separation. Hanford used the PUREX, Bismuth Phosphate, and REDOX processes, and reprocessed many wastes for recovery of uranium and fission products. Thus, Hanford has 55 distinct waste types, only 17 of which could be at Savannah River. While Hanford and Savannah River wastes both have high concentrations of sodium nitrate, caustic, iron, and aluminum, Hanford wastes have higher concentrations of several key constituents. The factors by which average concentrations are higher in Hanford salt waste than in Savannah River waste are 67 for ^{241}Am, 4 for aluminum, 18 for chromium, 10 for fluoride, 8 for phosphate, 6 for potassium, and 2 for sulfate. The factors by which average concentrations are higher in Hanford sludges than in Savannah River sludges are 3 for chromium, 19 for fluoride, 67 for phosphate, and 6 for zirconium. Waste composition differences must be considered before a waste processing method is selected: A method may be applicable to one site but not to the other.

I. INTRODUCTION

Stored tank wastes from Department of Energy (DOE) Hanford and Savannah River Sites have been compared based on currently available analyte database listings for each storage tank at each site. This has been done to facilitate the comparison of requirements and constraints imposed on waste treatment activities.

Both Savannah River and Hanford were separation sites for weapons-grade plutonium, where plutonium was separated from spent fuel. The only separation process employed at the Savannah-River Site was the PUREX process. Hanford used the PUREX process, but also employed the Bismuth Phosphate process and the REDOX process. The latter two processes, which were older and less efficient, produced more waste per fuel rod processed than did the PUREX. In addition to the three processes used for fresh spent fuel, Hanford also reprocessed some wastes in U-Plant to recover uranium. Lastly, many wastes were re-processed in B-Plant to recover cesium and strontium.[1]

Given that both sites employed the PUREX process, at least some of the wastes at the two sites might be expected to resemble each other. However, Hanford employed four major separation processes that Savannah River site did not. Thus, it would be reasonable to expect some very striking differences between the wastes at the two sites.

The present study employs two methods to make a high-level comparison of the waste at Savannah River and Hanford. In the first method, the number of waste types from each process at Hanford is cataloged, and the number of PUREX waste types is determined relative to the number of waste types resulting from other processes. In the second method, the average waste concentration in salt waste (supernatant and saltcake) and sludge is compared at the two sites.

II. METHOD OF COMPARISON

Two approaches are taken to evaluate the differences between Hanford and Savannah River waste. The first is simply to identify the number and percentage of waste types at Hanford that are associated with the PUREX process. This result is then compared to the total number of waste types at Hanford. Only the PUREX waste types can be at the Savannah River site, so in this analysis the number of waste types are identified that cannot be at the Savannah River Site. This was performed by subtracting

the number of PUREX waste types from the total number of waste types at Hanford.[2,3]

The average compositions at the two sites are also compared. This comparative evaluation added the current total amounts of select analytes for all tanks for the two DOE sites in the categories of sludge and supernatant/saltcake wastes. The analytes chosen are those that account for the bulk of the wastes and are of key interest in waste treatment activities. "Comparative Ratios" are calculated to enable direct comparisons between the data for the Hanford and the Savannah River sites.[4,5]

III. RESULTS AND DISCUSSION

I.A. Waste Type Analysis

A comparison of waste histories for the two sites can be made based on the known waste types at Hanford. There are 55 clearly identified and distinctly different wastes types that were produced at Hanford.[3] Seventeen of these can be assigned to the PUREX process, which was operated at both sites. The remaining 38 waste types are assigned to particular Hanford processes such as REDOX, B-Plant, Plutonium Finishing Plant and others and will not be found at the Savannah River Site.

I.B. Comparison of Waste Average Concentration

The calculated data results are given in Tables I and II. The "Comparative Ratios" shown are the ratio of the mass of a constituent in Hanford waste to the mass of that constituent in Savannah River waste, relative to the sodium masses at each site. For examples, the value of 0.7 for the "Comparative Ratio" for ^{90}Sr shown in Table I is obtained by taking the value of the "Analyte Ci/Sodium Mass kg" for ^{90}Sr in the Hanford waste and dividing it by the corresponding value of 0.0896 for ^{90}Sr in the Savannah River waste. Comparable absolute values may also be obtained by simply taking the ratio of the inventories at each site for each constituent, as the total mass of sodium is similar for the two sites.

Table I. Supernatant/Saltcake Wastes

	Hanford	Savannah River	Comparative Ratios
Analyte	**Analyte Ci/Sodium Mass kg**	**Analyte Ci/Sodium Mass kg**	
90-Strontium	0.0896	0.1307	0.7
137-Cesium	0.8259	2.1631	0.4
241-Americium	0.0006	0	67.5
	Analyte kg/Sodium Mass kg	**Analyte kg/Sodium Mass kg**	
Aluminum	0.0999	0.0264	3.8
Chromium	0.0108	0.0006	17.5
Cesium	0	0.0001	0.4
Fluoride	0.0197	0.002	9.8
Nitrate	1.1677	1.475	0.8
Nitrite	0.2481	0.1361	1.8
Phosphate	0.0735	0.0094	7.8
Potassium	0.0209	0.0039	5.4
Sodium	1	1	1
Sulfate	0.0788	0.0458	1.7

Highlights of the comparison between the average waste compositions are detailed in the following subsections.

I.B.1. Supernatant/Salt Cake Wastes

- The quantity of salt waste is less at Hanford (128,001,686 kg) than at Savannah River (155,279,011 kg). This may be because more of the salt waste is stored as saltcake at Hanford than at Savannah River, per the next bullet.
- The "Analyte Total Weight" (weight of the primary Supernatant/Saltcake constituents) at Hanford (115,034,042 kg) is similar to that at Savannah River (117,543,831 kg) indicating the waste at Hanford is drier.
- The "Comparative Ratios" indicate that relative to sodium concentration, Hanford supernatant/ saltcake wastes are more concentrated than those at Savannah River. Examples are:
  - ^{241}Am: by a factor of 67
  - Aluminum: by a factor of 3.8
  - Chromium: by a factor of 17.5
  - Fluoride: by a factor of 9.8
  - Nitrite: by a factor of 1.8
  - Phosphate: by a factor of 7.8
  - Potassium: by a factor of 5.4
  - Sulfate: by a factor of 1.7

In contrast, the Savannah River Site has a much higher concentration of ^{137}Cs than the Hanford salt waste. This can most likely be attributed to the fact that Hanford recovered much of the cesium from the waste during the fission-product recovery campaigns.[1]

Table II. Sludge Wastes

	Hanford	Savannah River	Comparative Ratios
Analyte	**Analyte Ci/Total Mass Sludge kg**	**Analyte Ci/Total Mass Sludge kg**	
137-Cesium	0.151	1.2085	0.1
241-Americium	0.005	0.0873	0.1
90-Strontium	1.6788	18.6252	0.1
	Analyte kg/Total Mass Sludge kg	**Analyte kg/Total Mass Sludge kg**	
Aluminum	0.1692	0.1155	1.5
Chromium	0.005	0.0016	3
Fluoride	0.0168	0.0009	18.8
Iron	0.04	0.1705	0.2
Lead	0.0024	0.0022	1.1
Manganese	0.0047	0.0328	0.1
Sodium	0.2307	0.0324	7.1
Nickel	0.0031	0.0095	0.3
Phosphate	0.0783	0.0012	67.2
Sulfate	0.0174	0.0038	4.6
Uranium	0.0207	0.0424	0.5
Zirconium	0.0151	0.0028	5.4

I.B.2. Sludge Wastes

- The "Sludge Waste Total Weight" is higher at Hanford (26,355,479 kg) than at Savannah River (4,311,392 kg) by a factor of 6.1. This is a direct consequence of the earlier REDOX and Bismuth Phosphate (B-Plant) processes being less efficient than the later PUREX process.[2] Both sites produced about the same amount of sludge waste from the PUREX process with Hanford at 4,492,253 kg and Savannah River at 4,311,392 kg (current waste inventories). The balance of the Hanford sludge waste (22,039,350 kg) accounts for eighty-five percent of the total sludge waste and is attributable to the thirty-eight non-PUREX waste streams only at Hanford and not at Savannah River.
- The "Comparative Ratios" indicate that Hanford sludge wastes are more concentrated than those at Savannah River in a number of key analytes. Examples are:
    - o Aluminum: by a factor of 1.4
    - o Chromium: by a factor of 3.0
    - o Fluoride: by a factor of 18.8
    - o Sodium: by a factor of 7.1
    - o Phosphate: by a factor of 67.2
    - o Sulfate: by a factor of 4.6
    - o Zirconium: by a factor of 5.6

The Savannah River Site sludge waste has a much higher concentration of ^{90}Sr than the average Hanford sludge. This can be attributed to three factors. First, Hanford recovered much of the ^{90}Sr from the waste during fission product recovery campaigns. Second, much of the older waste at Hanford was generated using less efficient plutonium recovery methods[1] that created more waste per fuel rod and diluted the ^{90}Sr concentration. Third, some of the waste at Hanford is older than the waste at Savannah River, giving the waste at Hanford a longer time to decay.

IV. CONCLUSIONS

Hanford has much more sludge waste than Savannah River and about the same amount of supernatant/saltcake waste. Hanford wastes may be more difficult to process in pretreatment and glass production activities because they have higher concentrations of aluminum, chromium, fluoride, phosphate, and sulfate in both the sludge and supernatant/saltcake wastes. This is a result of the differences in waste histories between the two DOE sites. Hanford had several different nuclear fuel separation processes that led to different waste types whereas Savannah River had only one.

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