VOLUME REDUCTION OF PLUTONIUM-CONTAMINATED SOIL

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J. H. Horton and E. L. Albenesius

Savannah River Laboratory
E. I. du Pont de Nemours and Company
Aiken, South Carolina 29801

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DISCLAIMER

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ABSTRACT

A series of simple laboratory experiments was conducted to test the feasibility of separation of plutonium-contaminated soil into plutonium-rich and depleted fractions. Water-scrubbing (agitation) and washing of a sample of soil from the Savannah River Plant burial ground separated out a clay-silt fraction containing about 95% of the plutonium, but comprising only one-third of the total soil; the remaining two-thirds of the soil was a sand that contained only about 5% of the total plutonium. The technique appears to be adaptable to commercial sand scrubbing and classifying equipment, and should be generally applicable to soils of high quartz sand content such as the clayey sands typical of the coastal plain of the southeastern United States.

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DETAILS

Samples of soil were taken from a trench filled with plutonium waste in 1964. Gamma pulse height analysis showed this soil contained 93 nCi of ^{239}Pu per gram; this was the only significant alpha emitter found.

The contaminated soil was used for laboratory tests of plutonium concentration methods. The test equipment is shown in Figure 1. Agitation for scrubbing was by magnetic stirrer. Water flow for classification was adjustable to remove different particle sizes. The plastic pipe above the flask damped rotation of the fluid and provided an appropriate cylinder to permit accurate calculation of the size particles eluted. Effluent clay-silt was collected in 150-ml portions, and the plutonium in each portion was determined by alpha counting.

Effluent plutonium decreased exponentially with the amount of effluent withdrawn as shown in the expression

$$\frac{C}{C_o} = e^{-bv}$$

where: C_o = initial concentration in effluent

C = concentration in effluent after a flow of volume, v

b = elution constant, v^{-1}

Values of C/C_o (normalized to C_o = unity) from each test were fitted to a linear plot against v by the least squares method.

Various "scrubbing" (agitation) times before wash flow began and various wash flows (all with continued scrubbing) were tested to determine their effects upon plutonium partitioning between the sand in the flask and the effluent slurry of clay-silt.

Typical effects of wash flow are shown in Figure 2 and in Table I.

The effect of scrubbing before washing is summarized in Figure 3. Flow was 569 ml/min to a total of 1500 ml. The pre-wash scrubbing substantially increased the rate of clay-silt-plutonium elution, with all tested pre-wash scrubbing times (5 to 20 min).

The test was repeated four times with 10-minute pre-wash scrubbing to determine variations between soil samples (dashed lines). The results indicate that little would be gained from further laboratory tests because scrubbing times vary with type of equipment and must be determined in full-scale equipment. However, these laboratory data do indicate that reasonable scrubbing will decrease the sand-fraction plutonium sufficiently to permit the sand to be returned to the burial trenches. Other data from these tests are summarized in Table II.

Two tests were continued at 569 ml/min to 3000 ml total wash after 10-minute scrubs. However, the extended washing had no effect on elution constant; pre-wash scrubbing is more important. The washed sand was 60 and 63% of the total soil, and 97.3% of the plutonium was in the clay-silt fraction. The possibility that the ^{238}Pu in the soil is in the form of tiny particles was verified by two 8-day autoradiographs (Figure 4) of suspensions of clay-silt fractions deposited on steel disks, dried, and coated with collodion.

Commercial scrubbers are expected to decontaminate the sand much more effectively than the laboratory apparatus, and commercial classifiers can remove any specified range of particle sizes. Equipment capable of processing 30 cubic meters (750 metric tons) of sand per day cost $50,000 to $100,000.

Little water would be needed because it can be recirculated. The clay-silt did not peptize but settled rapidly. After standing overnight, the wash water was clear and contained only 0.5 pCi α/ml. Eventually the recycled water will become turbid and must then be purified or discarded. Filtration should provide adequate purification. This phase of the study can probably not be evaluated in the laboratory, but could be done with pilot scale or production equipment using clean soil.

This method should be applicable to any soil containing a large fraction of sand regardless of the method of contamination with plutonium.

KEYWORDS: plutonium-contaminated, washing, scrubbing, clay-silt, sand, classification.

TABLE I

Effects of Wash Flow on Soil Classification

Scrubbed 10 min before washing; wash volume 1500 ml

Wash Flow, ml/min	*Washed Sand, % of soil*	*Largest Particle Eluted, μ*	*Plutonium in Clay-Silt Fraction, % of initial*
71	88	38	29.9
217	82	66	88.4
569	76	110	96.3

TABLE II

Effects of Pre-Wash Scrubbing on Soil Classification

Wash flow 560 ml/min; wash volume 1500 ml

Pre-Wash Scrubbing Time, min	*Washed Sand, % of soil*	*Plutonium in Clay-Silt Fraction, % of initial*
0	81	79.6
5	69	93.3
10	76	96.3
10	64	97.1
20	62	95.6

LIST OF FIGURES

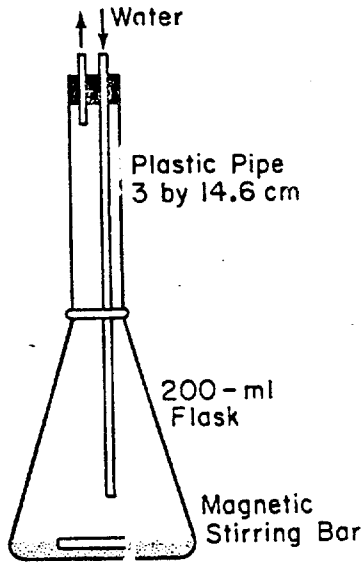

Fig. 1. Laboratory equipment for scrubbing and washing soil.

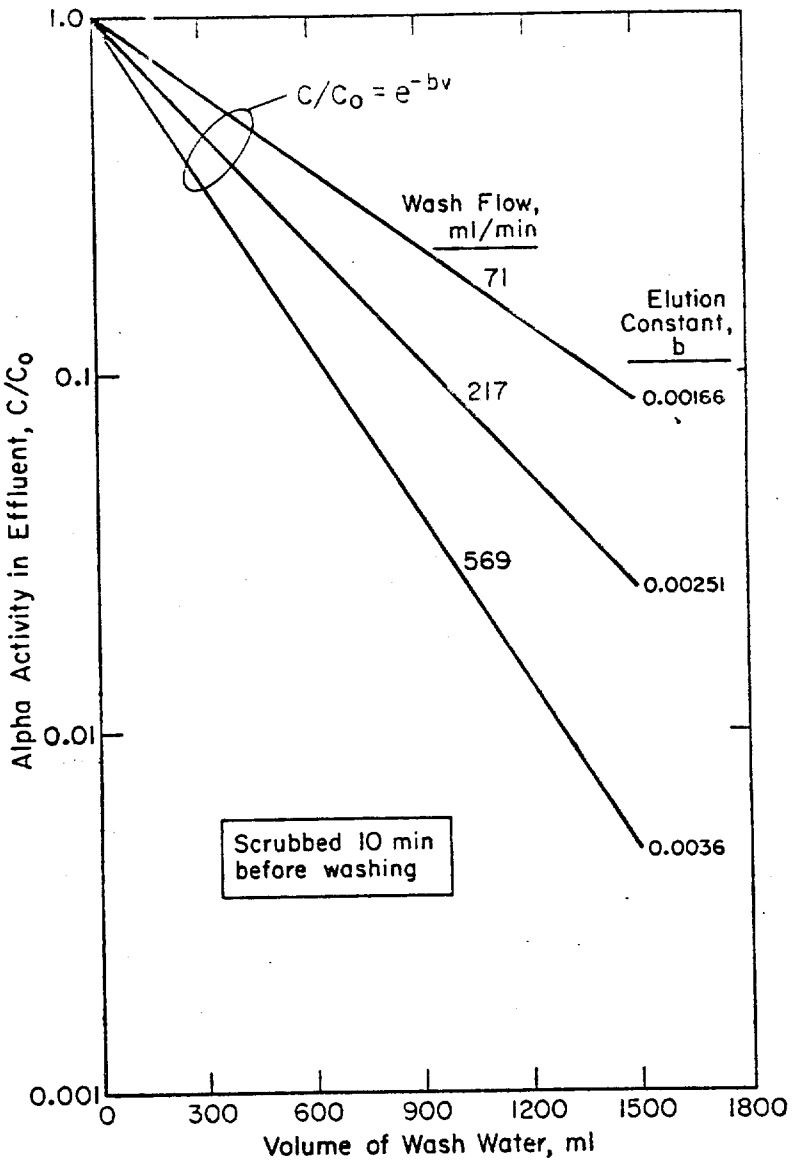

Fig. 2. Removal of ^{238}Pu from burial ground soil by scrubbing and washing at various flows.

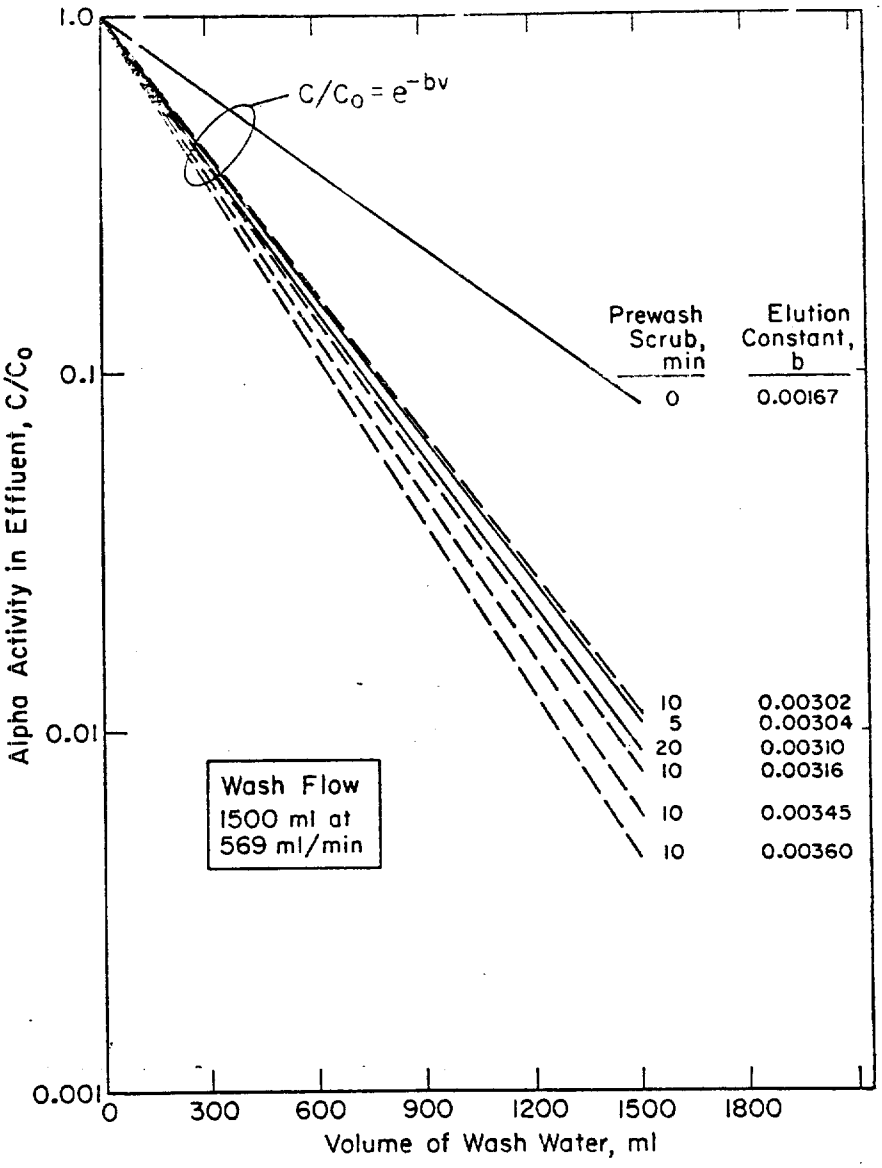

Fig. 3. Effect of prewash scrubbing time on washing of ^{238}Pu from burial ground soil.

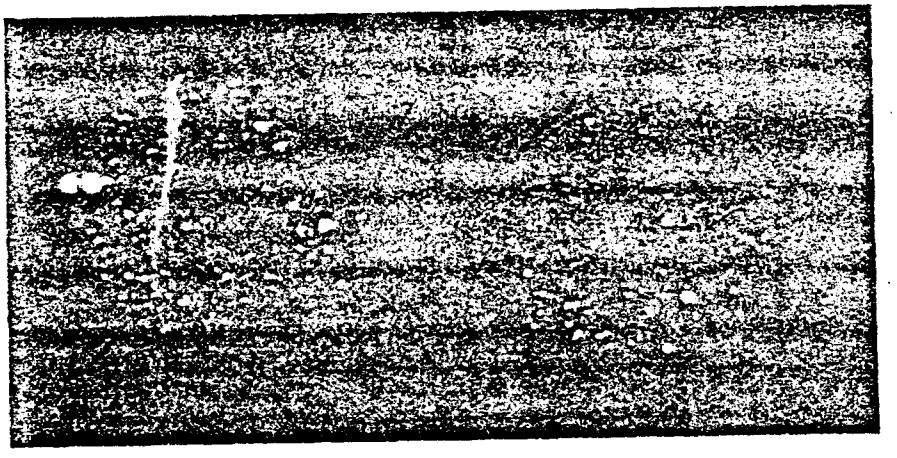

Fig. 4. Autoradiograph of clay-silt from burial ground soil.