ml sample was mixed with 5 ml of scintillation liquid for counting. Synaptosomes were treated similarly except that they were suspended in 0.32*M* sucrose and sedimented in a Beckman Airfuge ultracentrifuge. In the case of halothane and ethanol, which are volatile, the pellet-to-supernatant ratio was extrapolated to the time of pellet separation by measuring the ratio at several time intervals after separation of the pellet. To calculate the partition coefficient from the pellet-to-supernatant ratio, we determined the fractions of pellet volume occupied by lipids and water. Under our centrifugation conditions, the fraction of pellet volume occupied by lipid, f, was 0.12 for mitochondria and 0.07 for synaptosomes. It is easy to show (H. Rottenberg, unpublished manuscript) that if $^{14}Cp/^{3}Hp$ is the pellet ratio and $^{14}Cs/^{3}Hs$ is the supernatant cation, then $K_p = (^{14}Cp^{3}Hs)/(^{14}Cs^{3}Hpf) - 1/f$.

11. We thank S. Godfrey, R. Rudin, and K. King for excellent technical help and T. Ohnishi for the use of her EPR spectrophotometer. Supported by grant AA3442 from the National Institute of Alcohol Abuse and Alcoholism and grant GM 28173 from the National Institute of General Medical Sciences.

29 March 1981

Radiation Doses from Mount St. Helens 18 May 1980 Eruption

Recently published work by Fruchter *et al.* (*1*) characterizes the ash from the Mount St. Helens eruption of 18 May 1980 and provides a data base that can be used to estimate the radiation dose equivalent to individuals in the fallout area. Fruchter *et al.* reported relatively high concentrations of radon daughters (Table 1) in newly fallen ash in the vicinity of Richland, Washington, approximately 225 km due east of the volcano, with significantly smaller quantities of ^{226}Ra, ^{232}Th, and ^{40}K and a respirable dust fraction (< 3.5 μm) ranging from 1 to 3 percent by weight of the ash. Using these data as a starting point, it is possible to calculate the dose equivalent to the critical organs (lung and bronchial epithelium) from the 18 May eruption.

Inspection of the data in (*1*) indicates that about one-tenth of the activity was associated with particles of respirable size. An air sample collected at the Hanford Meteorological Station on 18 May showed a 24-hour (midnight to midnight) mean dust concentration of 10,600 μg/m^3 (*2*). The meteorologist reported the passage time for the Mount St. Helens cloud as ~ 5 hours (1100 to 1600). Assuming that essentially all the dust collected on the filter was from the Mount St. Helens plume, the mean dust concentration over the 5-hour cloud passage period is 5×10^4 μg/m^3 (0.05 g/m^3). If the dust collected at the Hanford Meteorological Station was similar in radioactivity concentration and particle size distribution to that reported by Fruchter *et al.*, then the activity reaching the bronchi and lungs from inhalation at the rate of 1.2 m^3/hour (*3*) over the 5-hour period is

$$270 \text{ pCi/g} \times 0.05 \text{ g/m}^3 \times 1.2 \text{ m}^3\text{/hour} \times 5 \text{ hours} \times 0.1 = 8 \text{ pCi}$$

Using dose conversion factors calculated by McPherson (*4*), the combined 50-year radiation dose equivalent from inhalation of the three radon daughters would be 4×10^{-6} rem to the bronchial epithelium and 1.5×10^{-6} rem to the pulmonary lung. These can be compared to a dose equivalent of ~ 3×10^{-4} rem received during a 5-hour period from inhalation of natural radon-thoron daughters normally present in the air, reported as an average for the continental United States (*5*).

Eventually, all of the radon daughters will decay to ^{210}Pb, which, because of its relatively low specific activity, would have an initial activity concentration of only about 1.7×10^{-6} that of the grandparent ^{214}Bi. However, because of its long half-life (22.3 years), this nuclide will remain in the environment for a long period of time. Estimates of potential dose equivalent commitments from lifetime inhalation of resuspended ^{210}Pb must take into account initial ground deposition, particle size, gradual agglomeration into larger size particles, weathering of the deposited ash, and wind profiles.

The depth of ash in the vicinity of the Hanford Meteorological Station was approximately 3 mm on 18 May. Taking the density of the ash as 2 g/cm^3, the total ^{210}Pb activity deposited is estimated as

$$3 \times 10^{-3} \text{ m} \times 2 \times 10^6 \text{ g/m}^3 \times 270 \text{ pCi/g} \times 1.7 \times 10^{-6} = 2.8 \text{ pCi/m}^2$$

where 270 pCi/g represents ^{214}Bi and 1.7×10^{-6} is the ratio of the activity of ^{210}Pb to that of ^{214}Bi. McPherson and Watson (*6*) integrated the resuspension equation of Anspaugh *et al.* (*7*) for a 50-year period and obtained a value of 8.9×10^{-3} day per meter. Applying this factor, an inhalation rate of 23 m^3/day (*3*), and the value of 2.8 pCi/m^3 for ^{210}Pb as the initial deposition yields a total of 0.57 pCi of ^{210}Pb inhaled, mostly in the first few years. Assuming this to be insoluble dust, the 50-year integrated dose equivalent to the lung is ~ 2×10^{-4} rem, with a similar dose equivalent delivered to bone from ^{210}Pb deposited there. These are insignificant in comparison to the dose equivalent of 5 to 10 rem received from normal levels of natural radioactivity over the same time period. Further, the estimated ^{210}Pb concentration in the ash, 4×10^{-4} pCi/g, is about 0.1 percent of the naturally occurring concentration of 0.3 pCi/g for soil in the vicinity of the Hanford Meteorological Station.

Table 1. Radionuclides in Mount St. Helens ash at Richland, Washington, 18 May 1980 (*1*).

Nuclide	Concentration (pCi/g)	Comment
^{214}Pb	212	Fresh ash fallout collected 3 hours 43 minutes after eruption
^{214}Bi	274	
^{214}Po	274	
^{226}Ra	0.376	
^{232}Th	0.088	
^{40}K	7.73	

J. K. Soldat
R. L. Kathren
J. P. Corley
D. L. Strenge

Battelle Pacific Northwest Laboratories, Richland, Washington 99352

References and Notes

1. J. S. Fruchter *et al.*, *Science* **209**, 1116 (1980).
2. J. P. Cooke, Air Pollution Control Authority, Richland, Wash., private communication.
3. International Commission on Radiological Protection, *Report of the Task Group on Reference Man* (ICRP Publ. 23, Pergamon, New York, 1975).
4. R. B. McPherson, "Environmental radon and radon daughter dosimetry in the respiratory tract" (Report PNL-2989, Pacific Northwest Laboratories, Richland, Wash., 1979).
5. *Natural Background Radiation in the United States* (Report 45, National Council on Radiation Protection and Measurements, Washington, D.C., 1975).
6. R. B. McPherson and E. C. Watson, "Environmental consequences of postulated plutonium releases from Westinghouse PFDL, Cheswick, Pennsylvania, as a result of severe natural phenomena" (Report PNL-2984, Pacific Northwest Laboratories, Richland, Wash., 1979).
7. L. R. Anspaugh, J. H. Shinn, P. L. Phelps, N. C. Kennedy, *Health Phys.* **29**, 571 (1975).

6 October 1980

0036-8075/81/0731-0585$00.50/0