

APPENDIX E

FECAL SAMPLING

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Fecal sampling can be a valuable aid for estimating the magnitude of an inhalation intake. Through application of the lung and digestive tract models (ICRP 1979), estimates can be made of the expected daily fecal excretion following an inhalation intake. For class W and class Y radionuclides, the expected fecal excretion can be divided into two components: that which represents rapid clearance from the respiratory tract and that which represents longer-term clearance from the pulmonary region of the lung. Measurement of the quantity of a class W or Y radionuclide excreted via feces in the rapid clearance phase (first few days following an intake) can provide an early estimate of intake that is often more sensitive than other bioassay measurements. This estimate may be especially helpful for class Y radionuclides with little absorption from the GI tract and for which in vivo counting is difficult, e.g., class Y forms of plutonium, uranium, ^{147}Pm . Additionally, fecal sampling during the rapid clearance phase may be helpful with more readily transported forms when the use of medication invalidates the use of normal systemic retention or excretion models, e.g., during chelation therapy.

BIOKINETICS

Figure E.1 shows the expected daily fecal excretion as a fraction of intake of 1- μm -AMAD particles for class W (curve A) and class Y (curve B) material for which radioactive decay, uptake from the gastrointestinal (GI) tract, and systemic excretion to the GI tract are negligible (from NUREG/CR-4884 [Lessard et al. 1987] using ^{239}Pu as the model). Nearly half of the intake is excreted via feces in the first 5 days, which makes fecal sampling a very sensitive indicator of intake at that time. Excretion during the next 5 to 10 days decreases rapidly, and the daily excretion beyond about 15 days is relatively constant, representing the slowly clearing component from the pulmonary. Note that excretion during the rapid clearance phase is

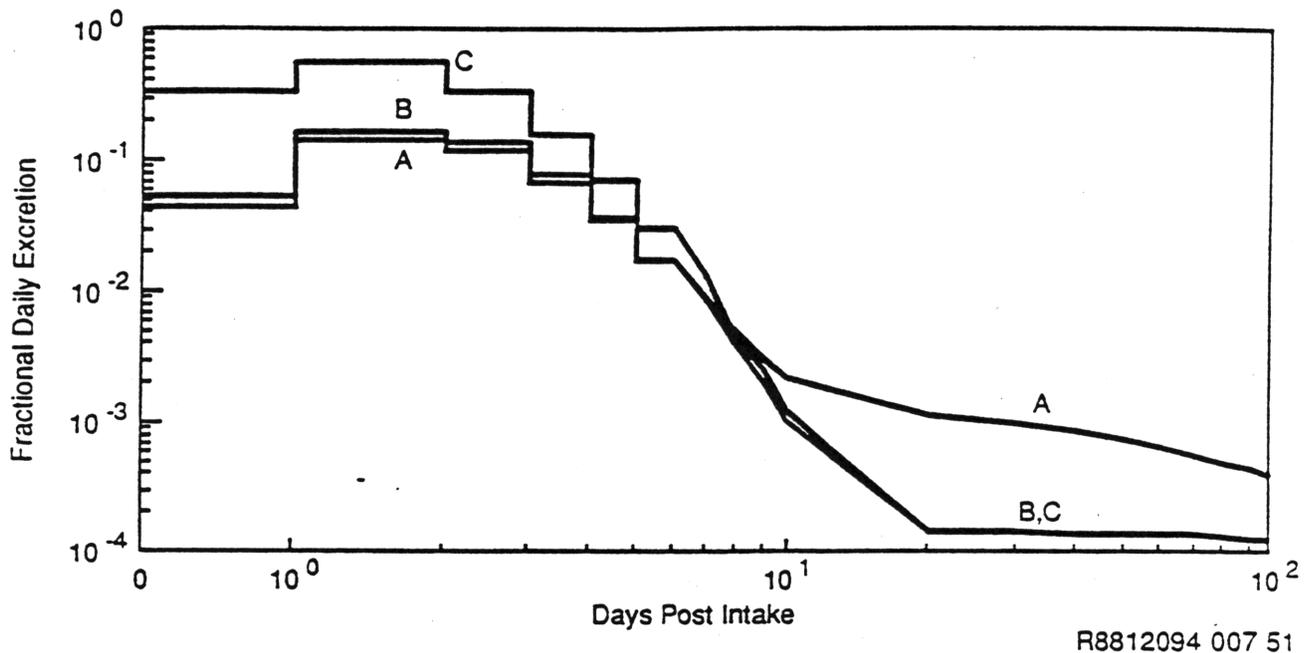


FIGURE E.1. Daily Fecal Excretion of Plutonium as a Fraction of Inhalation Intake for Three Intake Scenarios (all 1- μm -AMAD particle size)
 A -- inhalation of 1 unit of class W plutonium
 B -- inhalation of 1 unit of class Y plutonium
 C -- inhalation of 1 unit and ingestion of 1 unit of class Y plutonium

relatively independent of inhalation class, and that excretion after about 10 days is unaffected by ingestion that may have occurred along with the inhalation.

Table E.1 lists fecal excretion fractions and accumulated fractional excretion during the rapid clearance phase for the material described in the above paragraph (Lessard et al. 1987). Use of the accumulated fecal excretion data in Table E.1 is generally recommended over use of the daily fractional excretion data because of the difficulty in collecting (or at least in knowing that you have collected) a day's excretion. (See Pitfalls section for more discussion of this problem.)

TABLE E.1. Fraction of Intake Excreted via Feces Following an Acute Inhalation^(a)

<u>Days Post Intake</u>	<u>Fraction of Intake Excreted During Interval</u>		<u>Fractional Accumulated Excretion</u>	
	<u>W</u>	<u>Y</u>	<u>W</u>	<u>Y</u>
1 (0 - 24 hours)	0.042	0.052	0.042	0.052
2 (24 - 48 hours)	0.14	0.16	0.18	0.21
3 (48 - 72 hours)	0.11	0.13	0.29	0.34
4 (72 - 96 hours)	0.066	0.074	0.36	0.42
5 (96 - 120 hours)	0.034	0.036	0.39	0.45

(a) Assumes 1- μ m-AMAD particles and negligible uptake from the GI tract and negligible systemic excretion to the GI tract.

RECOMMENDATIONS FOR USE OF FECAL SAMPLING

Because of problems discussed in the Pitfalls section, fecal sampling is best used in combination with other bioassay measurements. When the quality of data from the other bioassay measurements is good, e.g., the data are not near the detection level or are not biased by the effects of medication, then preference should be given to estimates of intake from the other bioassay measurements.

However, for moderately or poorly absorbed radionuclides, fecal sampling during the first few days after an inhalation intake is a very sensitive indicator. Fecal sampling should be included as part of a regime of bioassay measurements for follow-up to a suspected intake if detectability of the intake using other bioassay measurements is greater than a first-year effective dose equivalent of 100 mrem.

The extent of use of fecal sampling depends on the expected severity of the intake. For intakes that are estimated (based on workplace monitoring) to result in a first-year effective dose equivalent of less than 100 mrem, or for situations where confirmation that an intake did not occur is desired, a fecal sample collected from 24 to 72 hours after the potential intake is recommended. If the sample shows detectable activity, additional bioassay measurements should be obtained, including additional fecal samples collected from 20

to 100 days post intake. In some situations these additional fecal samples may still be more sensitive to intake than other bioassay measurements, but special care is necessary to avoid further small intakes prior to collection of these additional samples. If the first sample is not collected or if the results are invalidated during analysis, another sample should be collected as soon as possible; however, samples collected from 5 to 20 days post intake should be used only as a confirmation (or otherwise) of intake, not as an estimator of intake, because of the steepness of the fecal excretion curve during this period.

If workplace monitoring results indicate a more serious intake, all fecal excretion from about 6 to 72 hours post intake should be collected. The total result from all samples collected during this period is divided by the fractional accumulated excretion for the first 3 days post intake to provide an estimate of intake. Table E.1 can be used for isotopes of plutonium and uranium (also other radionuclides where GI absorption and radioactive decay can be neglected); NUREG/CR-4884 (Lessard et al. 1987) can be used for other radionuclides (1- μ m-AMAD particles only).

If the estimate of dose from the intake exceeds a first-year effective dose equivalent of 100 mrem, and especially if other bioassay data cannot provide an adequate estimate of intake, then additional fecal samples at beyond 20 days post intake should be obtained and consideration should be given to determining the intake particle size distribution. The fractional daily fecal excretion at times after intake beyond 5 days can be obtained from the GENMOD code or from NUREG/CR-4884 (Lessard et al. 1987).

The fecal samples obtained after 20 days post intake can help determine the inhalation class and clearance rate from the pulmonary region to the GI tract. But it needs to be recognized that, despite appearances in the ICRP lung model, the clearance rate from the pulmonary region to the GI tract (compartment g [see Appendix D] is not necessarily identical to the clearance rates from the pulmonary region to the blood or lymph system (compartments e and h). Urine data provide the best estimates of the latter clearance rates. Lacking good urine data, default values should be used. For example, if fecal data indicate a long-term clearance half-time of 400 days and urine data are

lacking or are not definitive, the material should be assumed to be class Y and clearance half-times of 500 days should be used for compartments e and h.

NORMALIZATION OF FECAL DATA

Reference Man (ICRP 1974) excretion for adults ranges from 60 to 500 g/day, with a recommended average of 135 g/day for an adult male and 110 g/day for an adult female. Note that these values represent excretion "per day" not excretion "per bowel movement." When a single bowel movement is collected, it is generally interpreted as representing excretion for one day. If the sample is greater than 60 g, no normalization is used. If the sample is less than 60 g, the sample results should be normalized to 135 g for males and 110 g for females.

If total accumulated excretion over a time period was requested and there is no apparent reason to suspect that total excretion was not provided, then all sample results should be used as is, without regard for the mass of individual samples. If excretions were missed during the time period, then normalization of the total mass to the total mass expected based on the reference values given above should be used.

PITFALLS

There are problems with interpretation of fecal data for which the evaluator needs to stay alert. One is the possibility of interference by ingested material. In Figure E.1, curve C shows the expected daily fecal excretion from a unit intake of class Y material by inhalation and a unit intake by ingestion. Note that curve C follows the same general shape of the other curves, and hence a combined inhalation/ingestion intake of nearly equal proportions would not be readily discernible using early fecal data. Also note that the influence of the ingestion remains significant until about 8 days post intake. The accumulated fecal excretion in the first 3 days from this intake would be 3.5 times the accumulated fecal excretion from inhalation alone, and hence the estimate of intake determined in this manner would be 3.5 times too great. The point is that because ingested material contributes in toto to fecal excretion, it has a magnifying effect on the determination of

inhalation intake. For sufficiently large intakes, this problem can be overcome by sampling during the slow clearance phase.

Interpretation of fecal data is also sensitive to the size of the particles inhaled. For example, Figure E.2 shows fractional daily excretion for class W and class Y plutonium for 3- and 8- μm -AMAD particles. In these cases collection of the first 3 days' feces and assumption of 1- μm -AMAD particles would result in overestimation of the intake by 1.7 and 2.2 for intakes actually involving class W 3- and 8- μm -AMAD particles, respectively, and by 1.6 and 2.0 for class Y 3- and 8- μm -AMAD particles, respectively. Additional error would then be made in the calculation of doses to the lung and systemic organs because the fraction of intake deposited in the pulmonary region of the lung and/or transferred to the blood would be overestimated also.

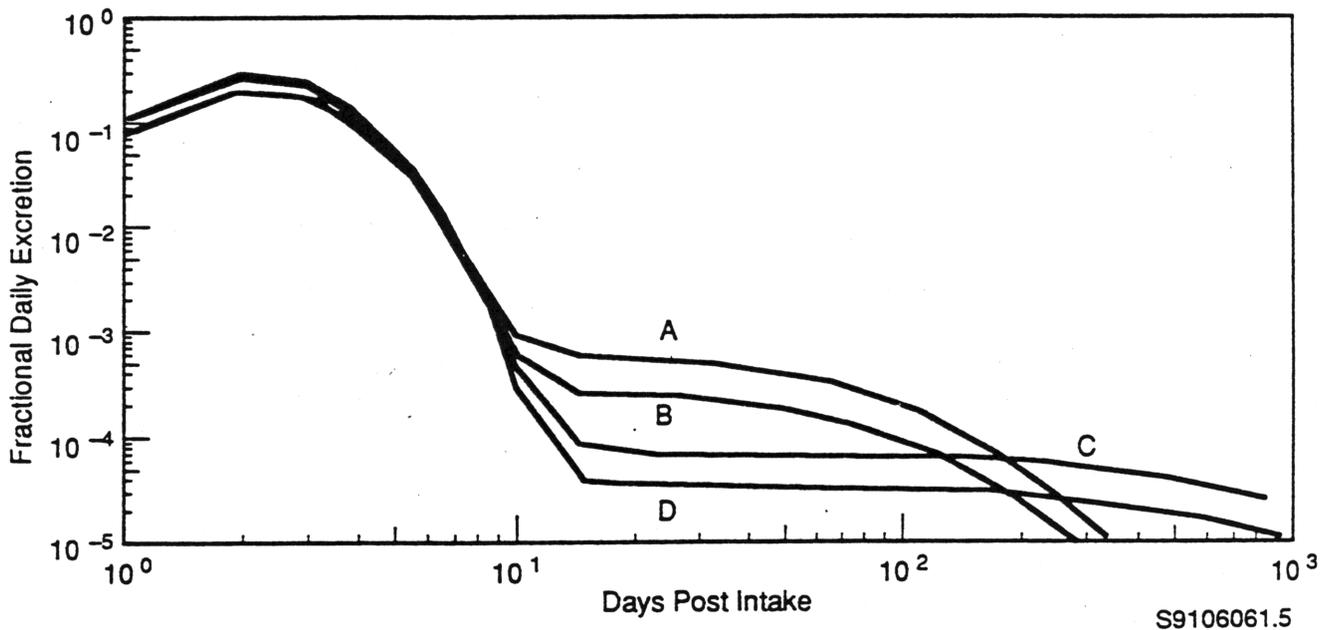


FIGURE E.2. Daily Fecal Excretion of Plutonium as a Fraction of Inhalation Intake for Four Intake Scenarios.
 A -- class W, 3- μm -AMAD particles
 B -- class W, 8- μm -AMAD particles
 C -- class Y, 3- μm -AMAD particles
 D -- class Y, 8- μm -AMAD particles

The GENMOD computer code can be used by adjusting deposition fractions to obtain fecal excretion fractions for particle-size distributions other than 1- μm AMAD.

Another difficulty arises from single-voiding samples. These are generally easier to obtain than total excretion over a specific period. But both inter- and intra-individual variation in the regularity of bowel movements can introduce large uncertainties if a single voiding is used to represent daily excretion. Normalization by mass can help reduce error when a single sample represents a fraction of a day's excretion, but it does not help when a single sample represents excretion for several days.

Contamination of a fecal sample by urine should be avoided, but generally should not introduce significant error if it should occur.

For uranium, natural daily ingestion (about 2 μg but variable [ICRP 1979]) needs to be taken into account.

REFERENCES

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