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Worker Safety and Radionuclide Intakes

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NNSA
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Introduction

Who we are (and what we do)

- Detect intakes of radionuclides using urine bioassay
- Confirm the people responsible for protecting workers from radiation are limiting or preventing intakes
- Internal Dosimetry Team Members

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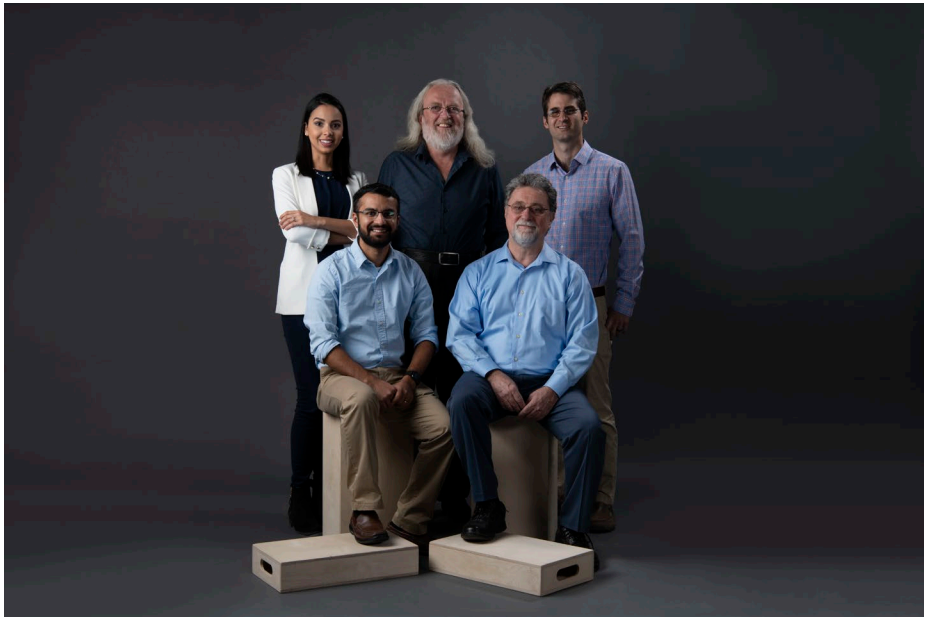


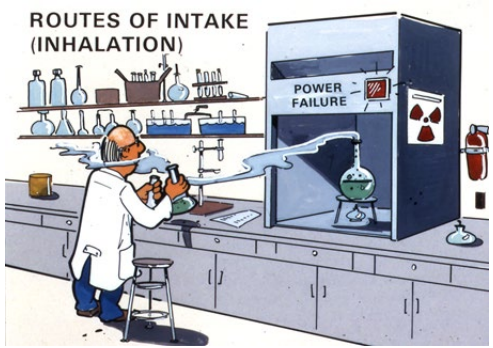
Radionuclide Intakes

- Plutonium or americium enter the body by inhalation, or a wound
- Stays in the body for decades. Committed Effective Dose (CED(50)) is the total dose an intake will cause over 50 years after it happens
- Radiation can’t escape the body, so we look in urine
- Almost never enough radiation to make employee sick
- Takes months and multiple samples to confirm
- Most “elevated” samples turn out to be false alarms

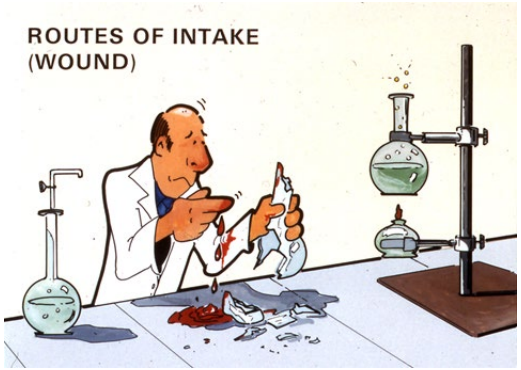
Intakes vs. Dose

- Intake is introduction of radionuclide into the body
- Dose is amount of radiation released by radionuclides in the body
- Doses from radionuclides in the body are called internal doses:
  -external doses are caused by sources outside the body (e.g., an x-ray machine)

How do intakes happen?

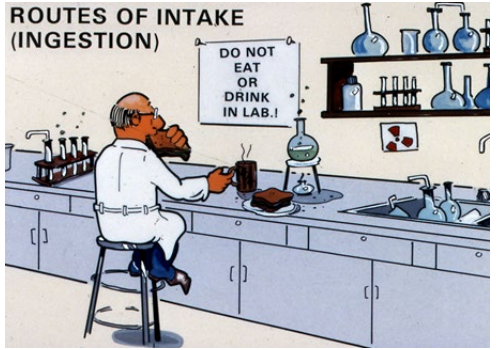


- Most common cause of intakes at the lab
- Most natural background comes from inhaling radon
- Detected by air monitors, nasal swabs



- Relatively uncommon

- Low absorption for actinides, not usually a concern
- Next largest contribution to natural background comes from ingesting radionuclides in food (e.g., ^{40}K in bananas)



Detecting and Reporting Intakes

How we detect intakes

We are alerted by…

- an elevated sample from routine bioassay monitoring
- an incident, such as a CAM alarm, injury, or contaminated clothing

We collect samples until we know…

- whether an intake happened (often takes many samples to be sure)
- when the intake happened (if possible)
- how the intake happened (if possible)
- the committed dose from the intake

After the investigation, we…

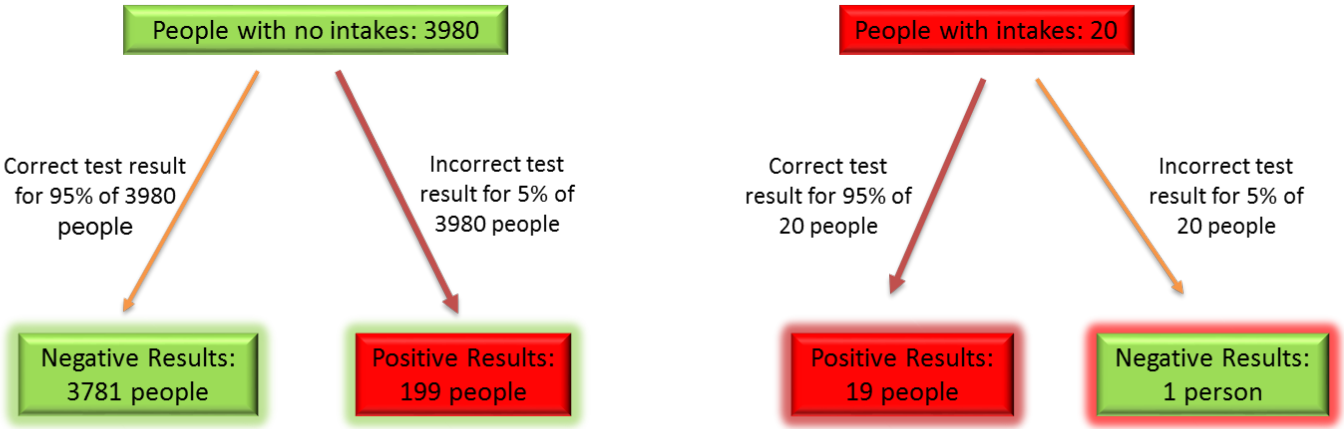
- let you know the results right away
- communicate our findings to managers, radiation safety officers, and regulators
- if needed, continue to answer questions for the affected workers and their families

Routine and Special Bioassay

- **Routine bioassay: regularly scheduled samples**
- **Elevated routine: a routine bioassay measurement shows more radionuclides than we expect**
- **Elevated routines and incidents require follow-up samples – special bioassay**
- **We use these follow-up (special bioassay) samples to determine if there has really been an intake**

False Alarms

1. Suppose we test 4000 people. Of those, 20 have had intakes.
2. Suppose test is right 95% of the time.
3. 218 people get positive results. Of those, 199 had no intakes.



An illustration showing why even very accurate tests can lead to false alarms. In this case, even though the test was right 95% of the time, only about 10% of people who got positive test results actually had an intake!

Why we sometimes need a lot of samples

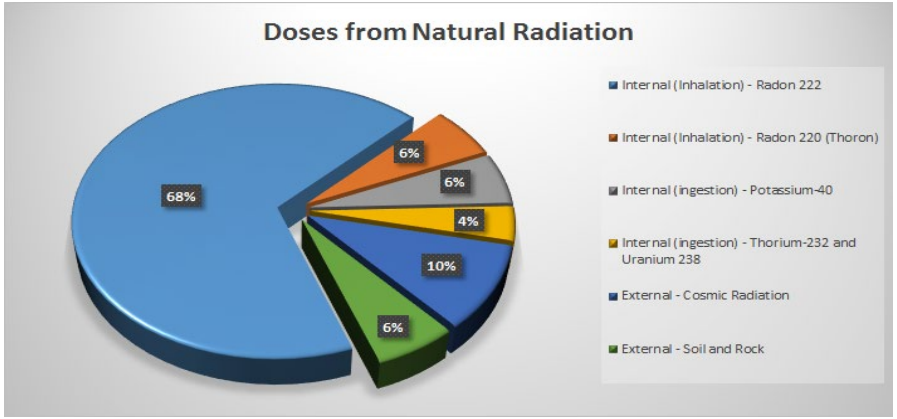
- Avoid false positives: <u>up to 10 samples needed to confirm an intake</u>
- "High" sample is still tiny (e.g., 10^{-15} grams per day for ^{238}Pu)
- Background radiation
- Samples sometimes get contaminated during analysis

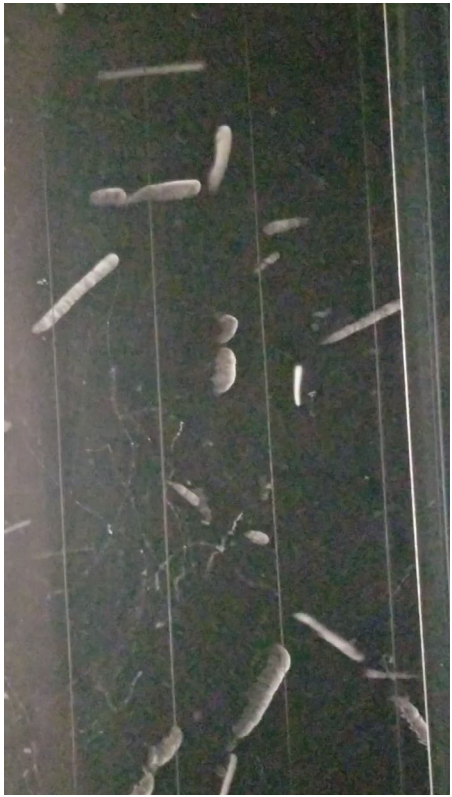
Background Radiation

- Common reason for false alarms, and a useful reference when asking, “should I be worried?”

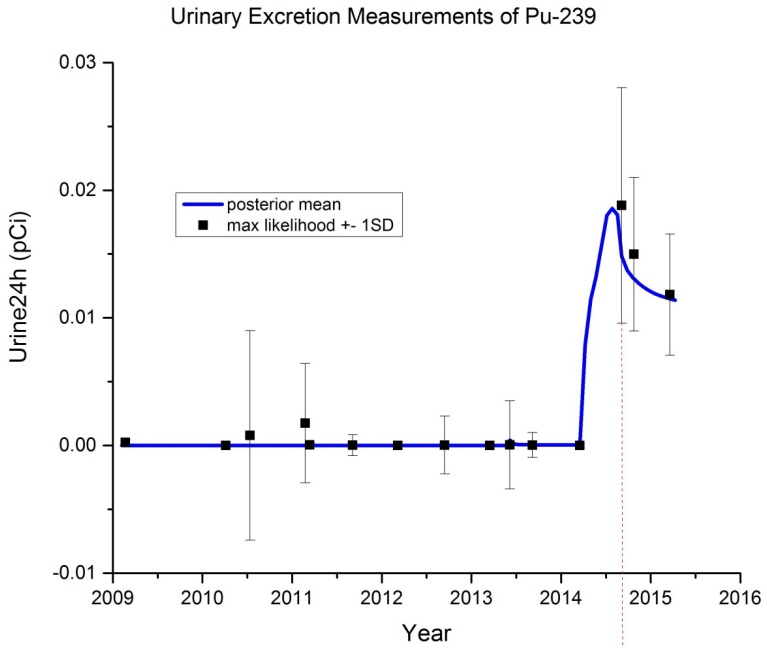
- Dose from background varies depending on geology and elevation:
  - -Florida: 131 mrem/year (50 year CED = 6,550 mrem)
  - -South Dakota: 962 mrem/year (50 year CED = 48,100 mrem)
  - -Los Alamos: 520 mrem/year (50 year CED = 26,000 mrem)

- Most natural background is radon inhalation (like plutonium, an internal alpha emitter)



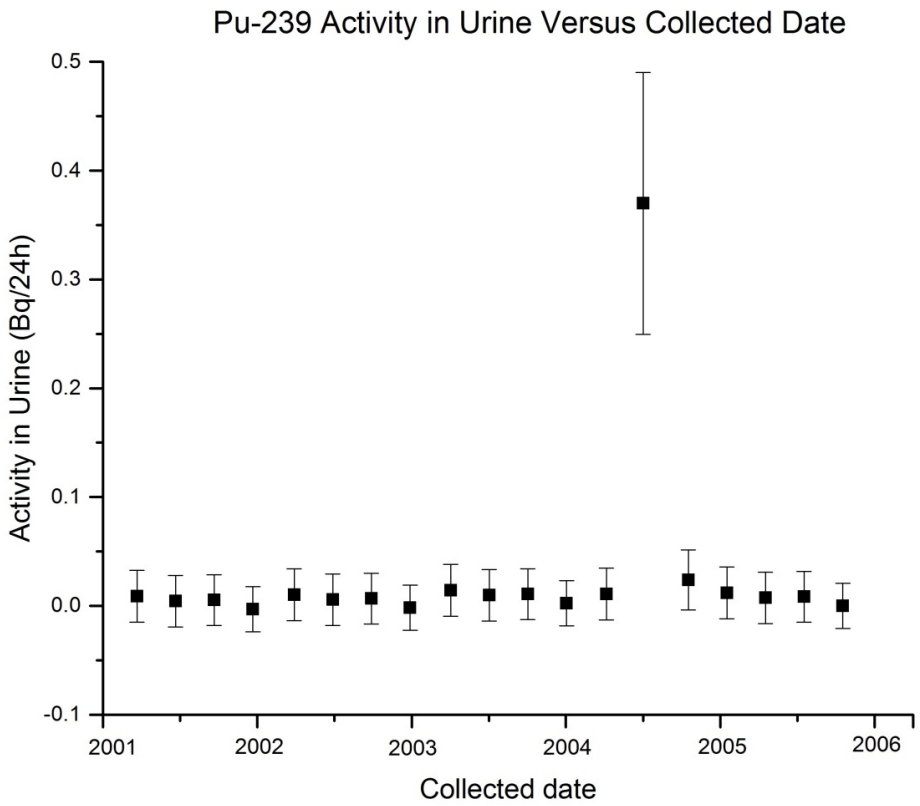


An intake case

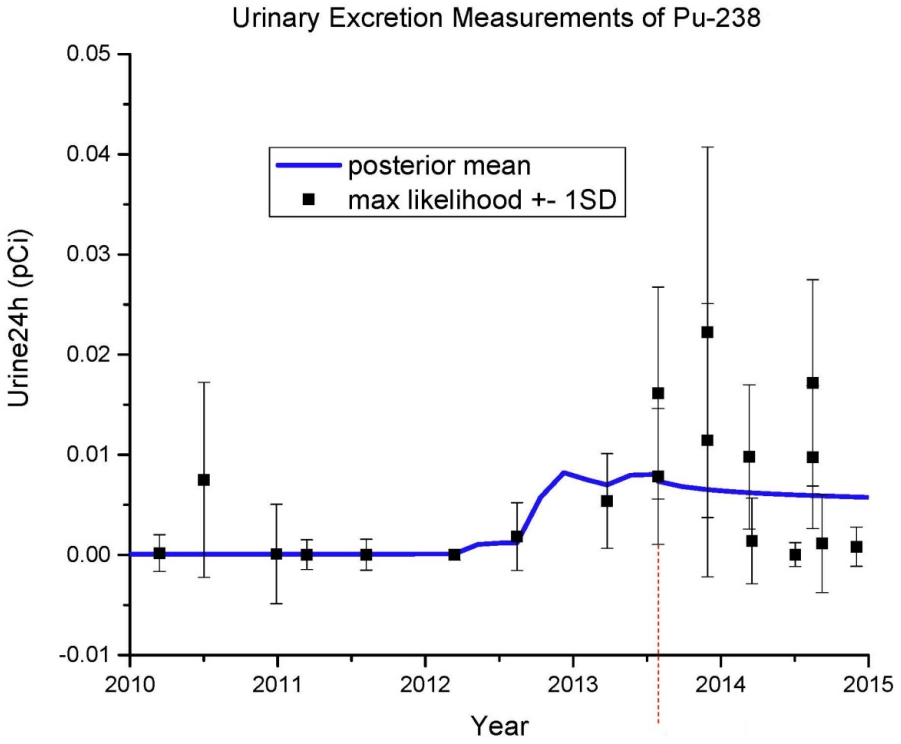


Urine bioassay data from a plutonium-239 intake. Each black square represents the result of a single urine sample. The thin vertical lines represent the statistical uncertainty on the measurement. The blue line represents the most probable value of the actual amount of radioactivity in urine being excreted over 24 hours.

An “no intake” case



Intake or No Intake?



Health Effects

Cancer

- Cancer risk increases by 0.5% per 10,000 mrem (only for doses greater than 10,000 mrem)
- 7 cases since 1985 larger than 10,000 mrem
- Largest internal dose ever at LANL: 312,000 mrem (1971)
- What is the risk from 1,000 mrem?
  -Conservatively, the increased risk of fatal cancer is 0.055%.
  - About 40% of Americans get cancer, half of those die
  -So, 1,000 mrem increases an individual's chances of fatal cancer from 20% to 20.055%
  -Note: this increase is so small that no one has been able to detect it

Radiation Sickness

- Largest internal dose ever at LANL: 312,000 mrem (1971)
- All at once, 312,000 mrem is enough to cause radiation sickness, but distributed over 50 years . . .
- Dose rate matters. If you receive 1,000,000 mrem all at once it will kill, but over 50 years won't even make you sick
- Analogy: a bottle of whiskey in one sitting vs. over 50 years
- No one at LANL has ever gotten radiation sickness from an intake

Psychological Effects

- **Months-long investigation and many bioassays**
  -Anxiety has time to grow
  -May imagine dose is larger with each sample request

- **Results are difficult to understand, lots of uncertainty**

- **Actinides remain in body for life: intake goes home with you**

- **We make things worse…**

Case Study: Tc-99 Incident

- Tc-99 (HL: 211,000 years) accidentally released
- In spite of long half-life, Tc-99 is rapidly cleared by the body
- Ingestion of all of the released material: <6 rem
- Nonetheless, employee's car was confiscated and destroyed

Case Study: Hanford Tunnel Collapse

- **Spread of contamination at Plutonium Finishing Plant in June 2017.**
- **31 workers tested positive for Pu-239, largest 50-year CED estimated 10 mrem.**
- **Excerpts from NBC King 5 local news coverage:**
  "…worker tested positive for inhalation of the potential lethal nuclear isotope of plutonium."

  " 'I'm pissed. I'm scared, like we all are, that sooner or later… I'm going to end up with cancer,' said the contaminated worker.'"

  "Thirty-one [workers] inhaled plutonium, which emits alpha radiation, the worst kind of radiation to get inside your body."

  "I was angry. You carry that with you the rest of your life. It's a cancer causer."

  "When they told me it was like an x-ray, I said, that's not true. An x-ray does not stay with me forever and this will. I know that alpha is a cancer causer. They know better and they are minimizing it."

An intake does NOT make you a danger to others

- The radiation from plutonium, americium, and tritium cannot penetrate your skin or leave your body: it is not contagious
- It is safe to shake hands, cuddle children and pets, sleep next to your spouse
- Cannot pass radioactive materials to another person through kissing or sex
- The best thing you can do is talk to family and friends – don't hesitate!

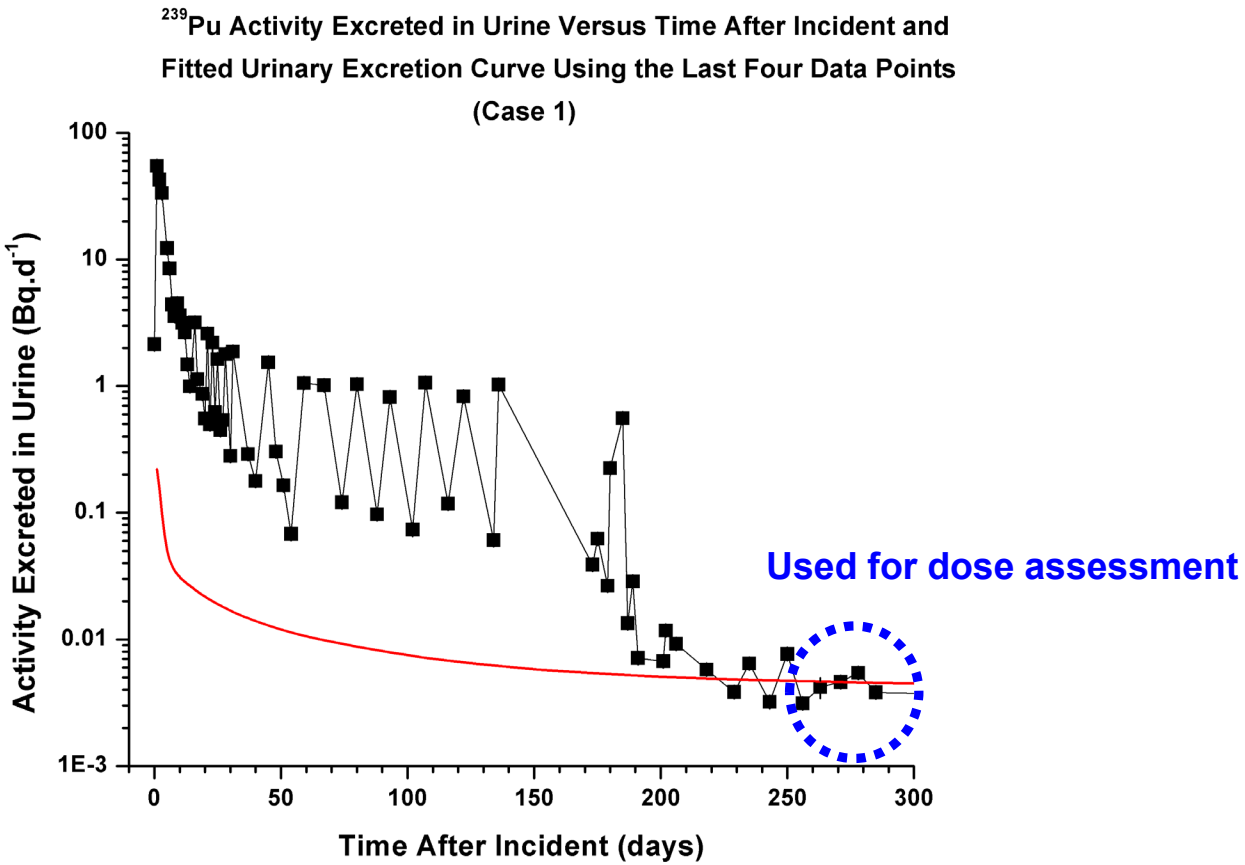
What happens if there is a big incident?

- If there is a major incident – e.g., a contaminated wound or a large airborne release, you may go to occupational medicine
- At occupational medicine, you may receive a wound count, or be asked to have a chest (lung) count
- If a wound, an attempt will be made to decontaminate. Doctor may recommend excision.
- Based on field indicators (CAM, nasals, wound counts, etc.), chelation may be offered
- Chelation delays dose estimate by several months

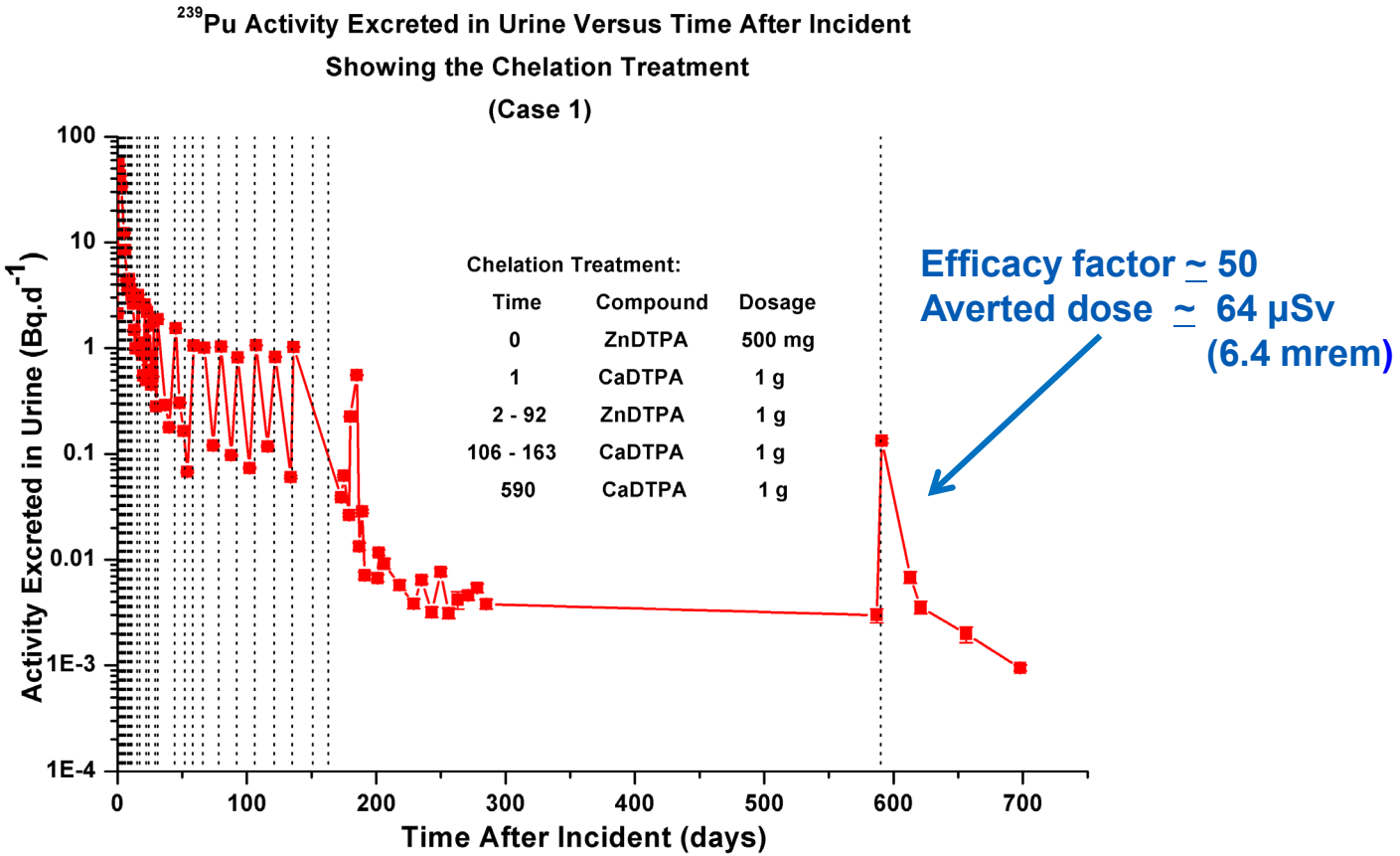
Chelation

- Chelation removes plutonium and americium from the blood
- Materials only stay in blood for a few days before depositing in organs, so chelation usually only works shortly after intake
- Also removes important metals like, calcium, zinc, and manganese – you need to take a multi-vitamin with it
- Can cause side-effects like headaches, upset stomach, muscle cramps
- Not usually recommended for pregnant women (causes birth defects in dogs)

Chelation


239Pu Activity Excreted in Urine Versus Time After Incident and Fitted Urinary Excretion Curve Using the Last Four Data Points (Case 1)
Activity Excreted in Urine (Bq.d-1)
100
10
1
0.1
0.01
1E-3
0
50
100
150
200
250
300
Time After Incident (days)
Used for dose assessment

Chelation


239Pu Activity Excreted in Urine Versus Time After Incident
Showing the Chelation Treatment
(Case 1)
Activity Excreted in Urine (Bq.d-1)
100
10
1
0.1
0.01
1E-3
1E-4
0
100
200
300
400
500
600
700
Time After Incident (days)
Chelation Treatment:
Time Compound Dosage
0 ZnDTPA 500 mg
1 CaDTPA 1 g
2 - 92 ZnDTPA 1 g
106 - 163 CaDTPA 1 g
590 CaDTPA 1 g
Efficacy factor ~ 50
Averted dose ~ 64 µSv
(6.4 mrem)

If all else fails…

J. RADIAT. RES., 43, 237–245 (2002)

Drinking Beer Reduces Radiation-induced Chromosome Aberrations in Human Lymphocytes

MANAMI MONOBE[1,2] and KOICHI ANDO[2*]

Beer / Radioprotection / Chromosome aberration / X rays / Heavy ions

We here investigated and reported the effects of beer drinking on radiation-induced chromosome aberrations in blood lymphocytes. Human blood that was collected either before or after drinking a 700 ml beer was in vitro irradiated with 200 kVp X rays or 50 keV/μ m carbon ions. The relation between the radiation dose and the aberration frequencies (fragments and dicentrics) was significantly ($p < 0.05$) lower for lymphocytes collected 3 h after beer drinking than those before drinking. Fitting the dose response to a linear quadratic model showed that the alpha term of carbon ions was significantly ($p < 0.05$) decreased by beer drinking. A decrease of dicentric formation was detected as early as 0.5 h after beer drinking, and lasted not shorter than 4.5 h. The mitotic index of lymphocytes was higher after beer drinking than before, indi-

Summary

- We (internal dosimetrists) use urine bioassay to look for intakes
- It takes a lot of samples to confirm that an intake really happened
- Most intakes significantly smaller than natural background
- Most significant effect is usually psychological
- You can help protect your colleagues by providing support and understanding
- We are always available to talk or answer questions

Thank You!

Questions?