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Argonne NATIONAL LABORATORY

HIGH PRESSURE DECONTAMINATION OF BUILDING MATERIALS: UNDERSTANDING REMOVAL MECHANISMS AND WASTE PRODUCTION DURING URBAN RADIOLOGICAL RECOVERY

WILLIAM JOLIN[1], MATTHEW MAGNUSON[2], AND MICHAEL KAMINSKI[1]

[1]ARGONNE NATIONAL LABORATORY

[2]USEPA HOMELAND SECURITY RESEARCH CENTER

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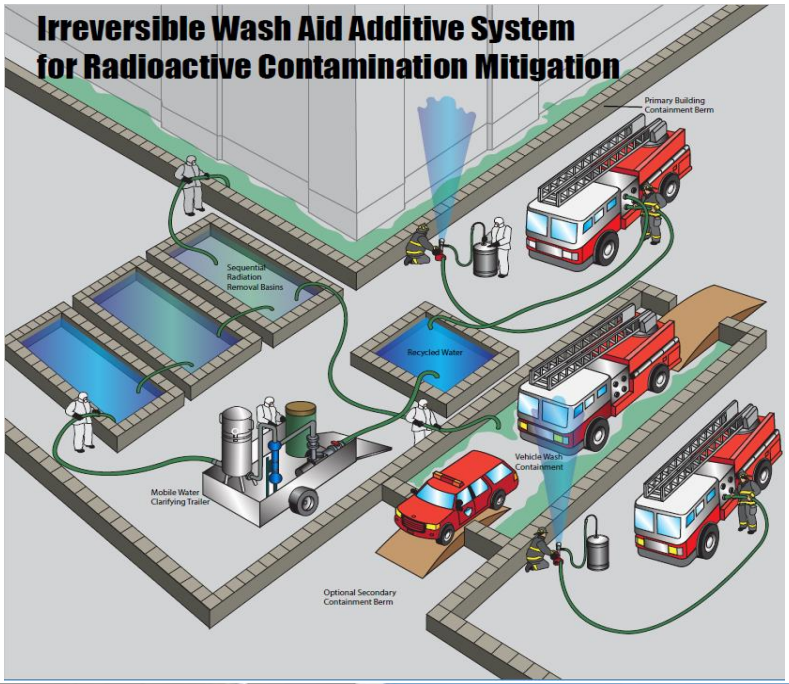
INTRODUCTION

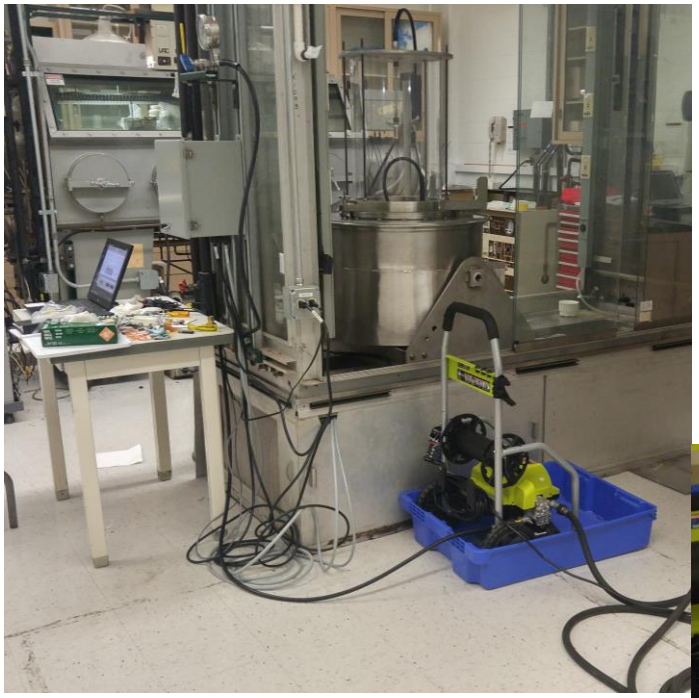
Rapid wide area decontamination

- Reduce dose to first responders
- Reopen critical infrastructure:
  - Response vehicles
  - Roadways
  - Hospitals
  - Airports
- Need readily available methods
- Guidance documents



Kyodo/Reuters

HIGH PRESSURE DECONTAMINATION (HPD) EXPERIMENTAL CHAMBER



HPD CHAMBER OPERATION

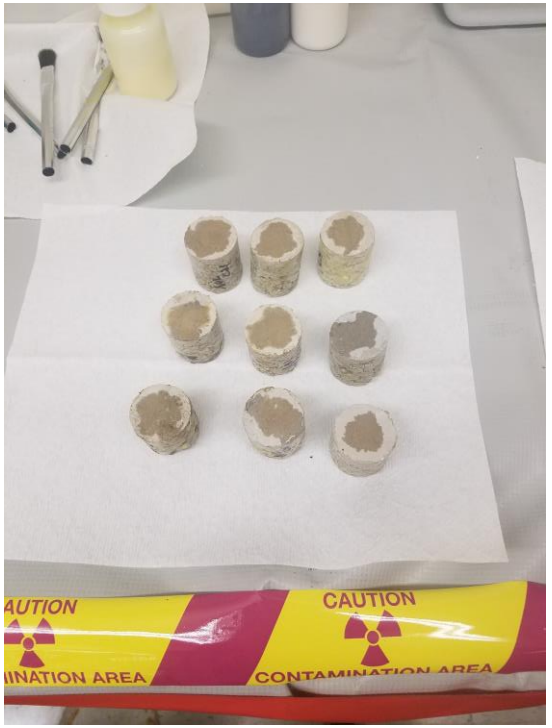
- Removals from:
  - Chemical: ion exchange, dissolution
  - Physical: surface ablation

- We can control:
  - **Movement speed**
  - **Coupon type**
  - *Nozzle angle*
  - *Wand length*
  - *Different solutions*
  - System angle
  - Number of passes
  - Offset angles

- CHEM/BIO also possible

RADIONUCLIDE APPLICATION

- Coupons spiked with solution containing:
  - **Cs-137**: strong interaction with minerals
  - **Sr-85** (Sr-90): somewhat insoluble
  - **Eu-152** (other lanthanides, Am-241): insoluble, strong interactions
- Aged for 24 hours or 8 days open to the atmosphere (humidity low and monitored)
- Depth profile determined by grinding on sand paper
- Mass removed used to create depth profiles:

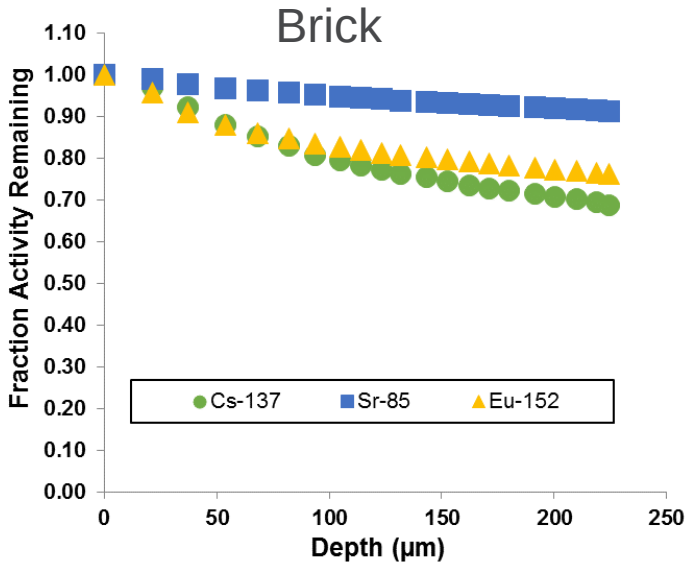


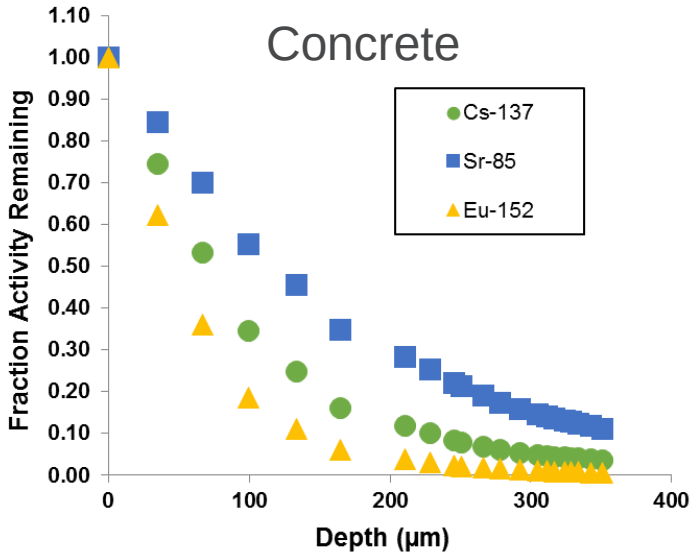
$$f_{act,i} = \frac{CPM_i}{\sum CPM \Big/ f_{removed}}$$

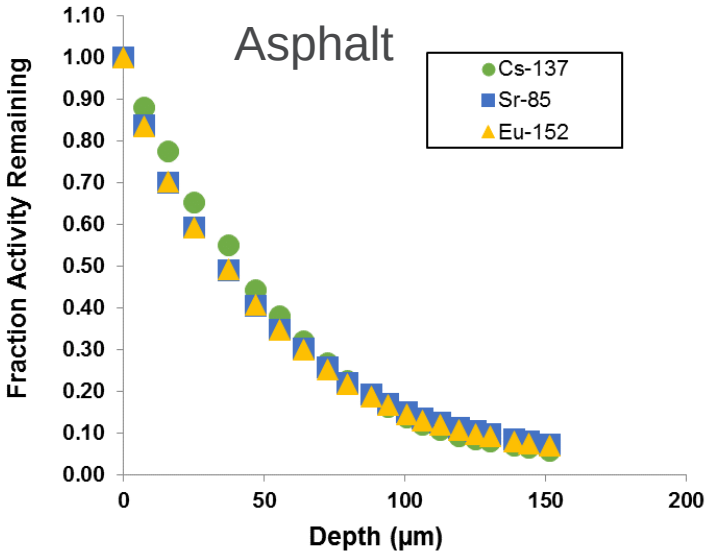
RADIONUCLIDE PENETRATION

24 hours after deposition

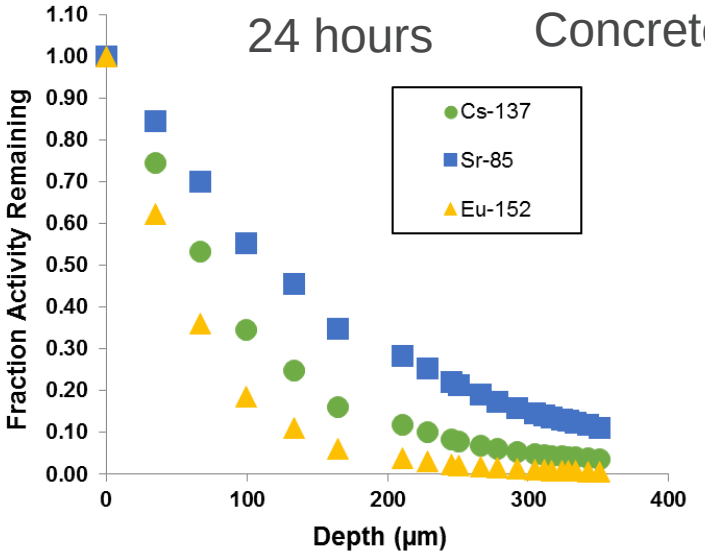
- Penetration of all radionuclides followed:
  - Brick > Concrete > Asphalt
  - From this we can already establish which surfaces to HPD
- Brick: Sr > Eu ≥ Cs
  - Sorption dependent
- Concrete: Sr > Cs > Eu
  - Sorption/precipitation dependent
- Asphalt: Sr ≈ Cs ≈ Eu

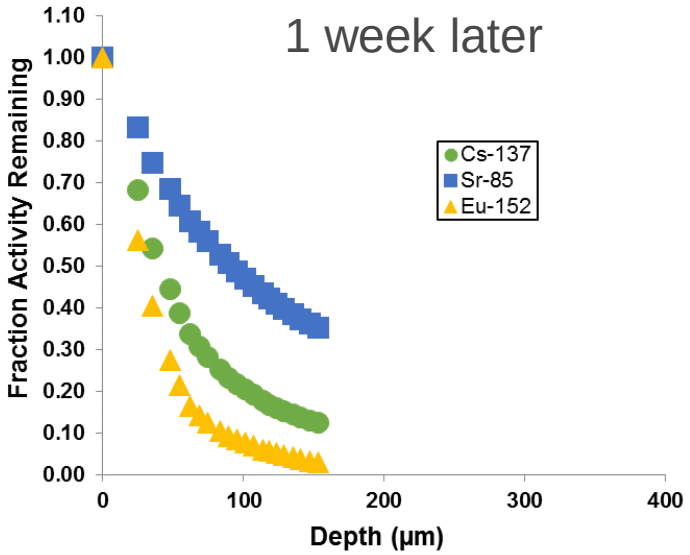


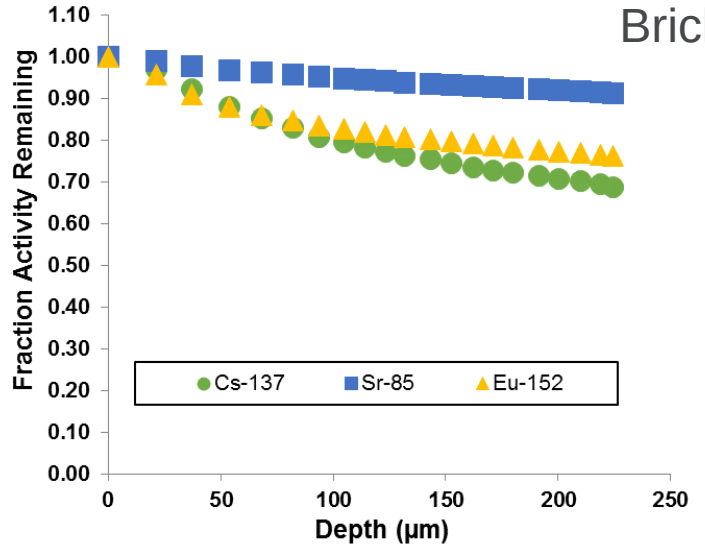


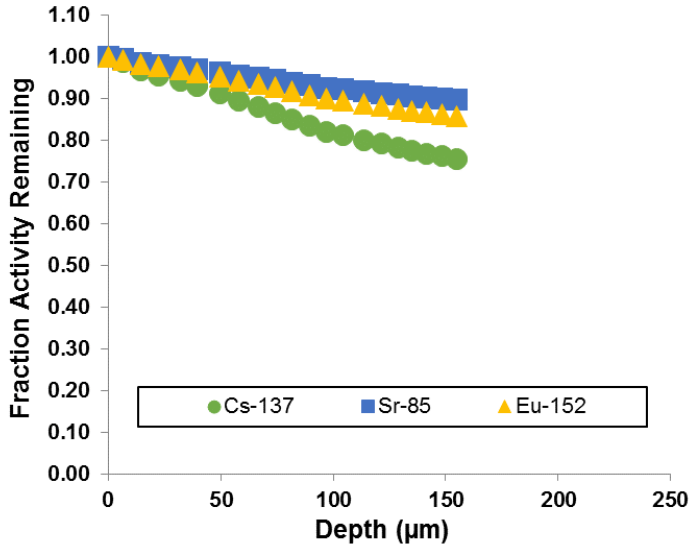


RADIONUCLIDE PENETRATION







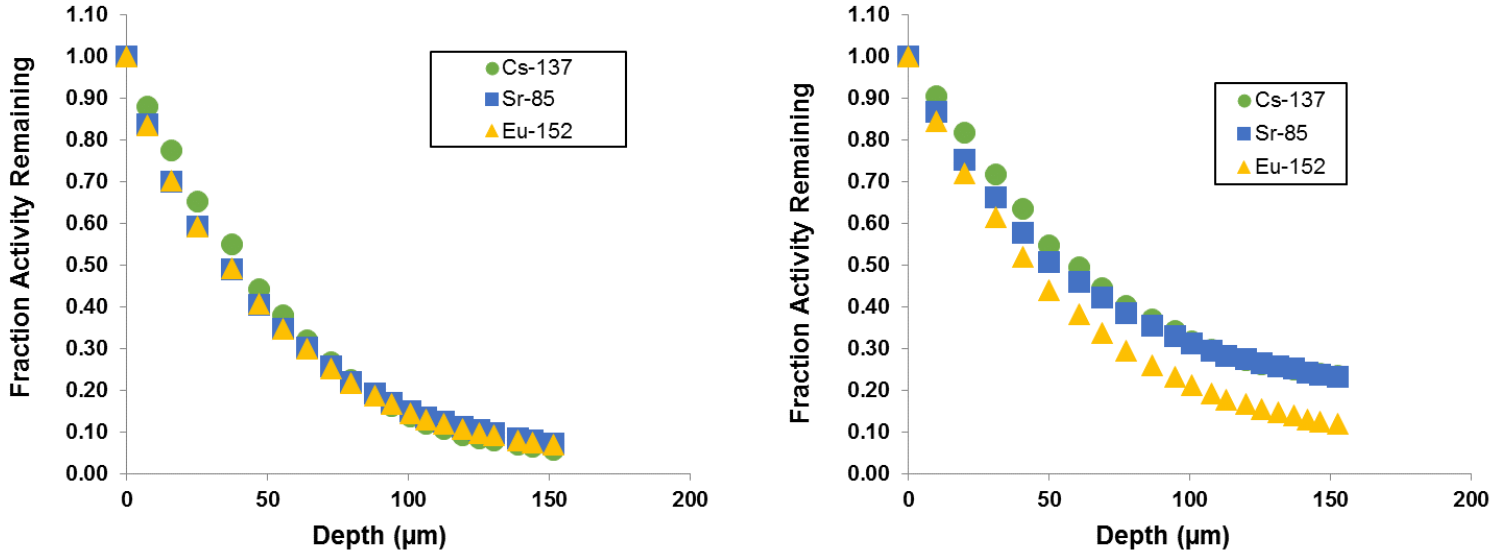


RADIONUCLIDE PENETRATION

1 week later: conclusions

- Penetration again followed:
  - Brick > Concrete > Asphalt
- Brick: Eu penetrates deeper
- Concrete: No obvious change
- Asphalt: Cs and Sr penetrate deeper

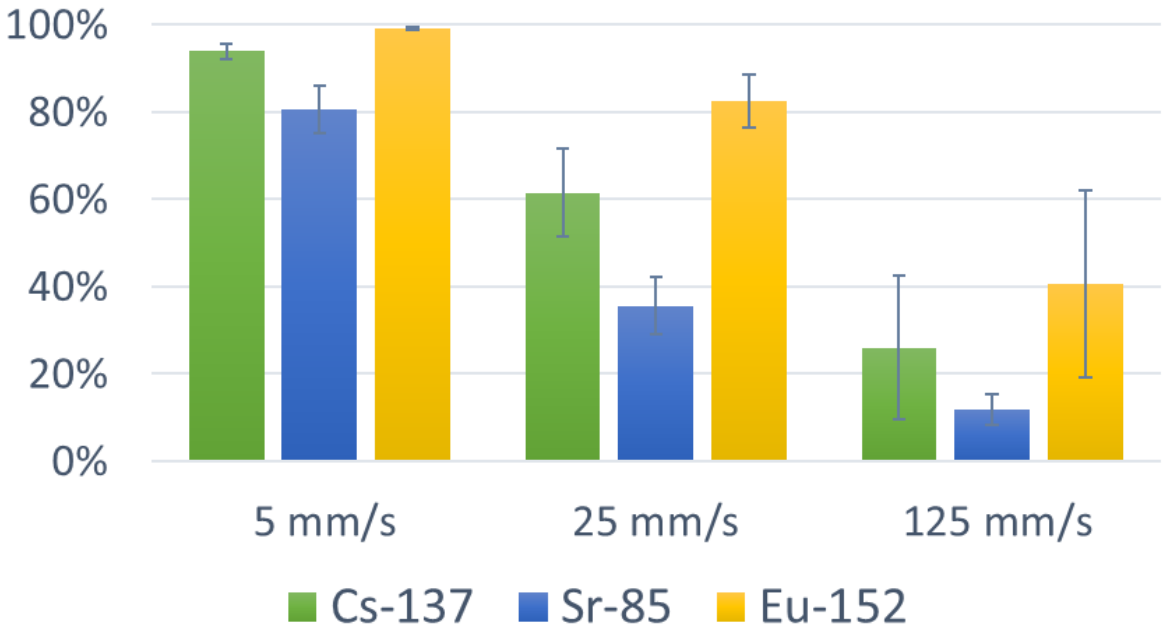
Asphalt



HIGH PRESSURE REMOVALS

Speed through spray path

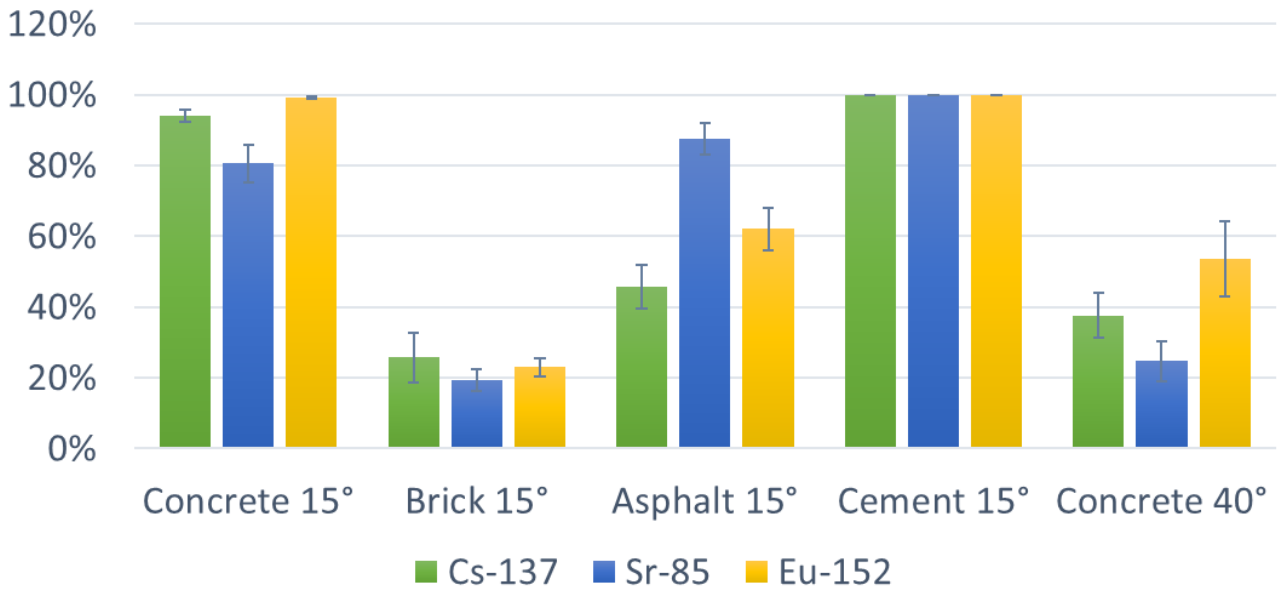
- HPD was performed after 24 hours of aging
- First we looked at concrete coupons with various speeds through the spray path
- Removals from concrete decreased and become less precise with increased speed through the spray path



HIGH PRESSURE REMOVALS

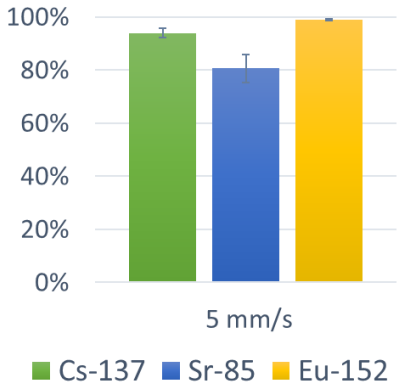
Different surfaces types

- HPD was performed after 24 hours of aging
- Removals was generally dependent on penetration distance and coupon “strength”
- Exception: High removals of Sr-85 from asphalt

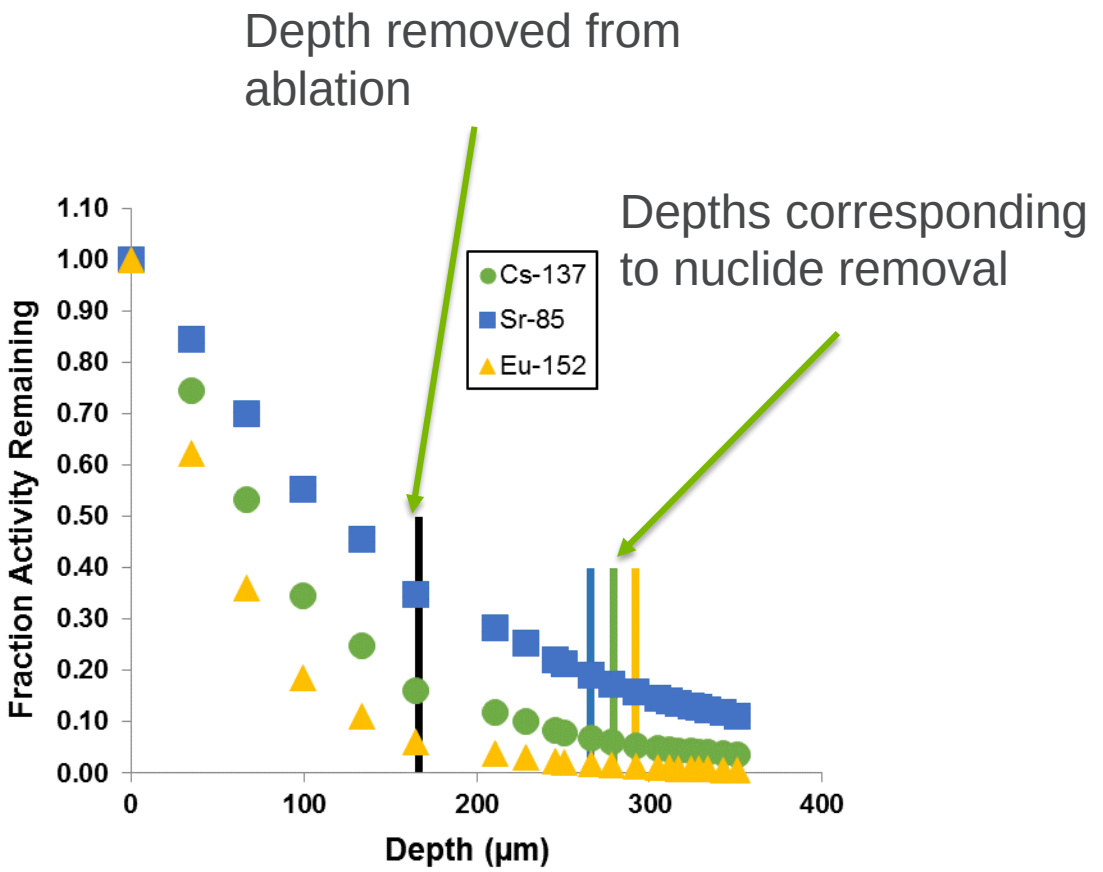


REMOVAL MECHANISMS

Comparing mass removed and radionuclide removal

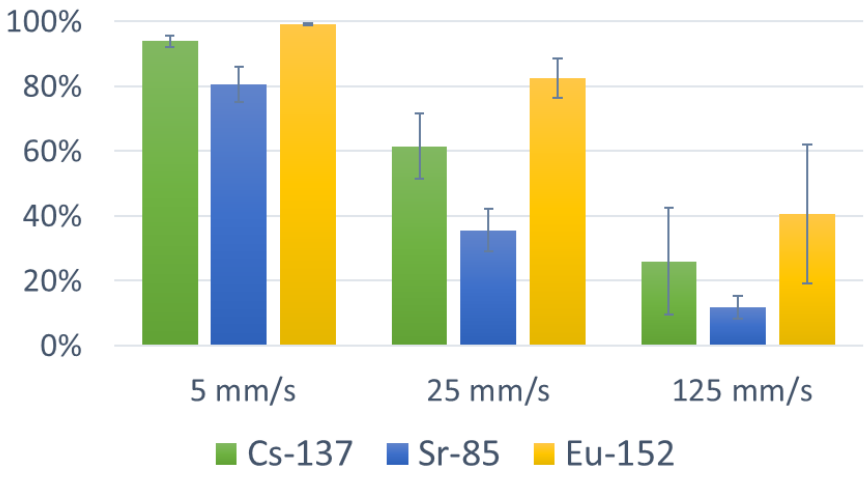


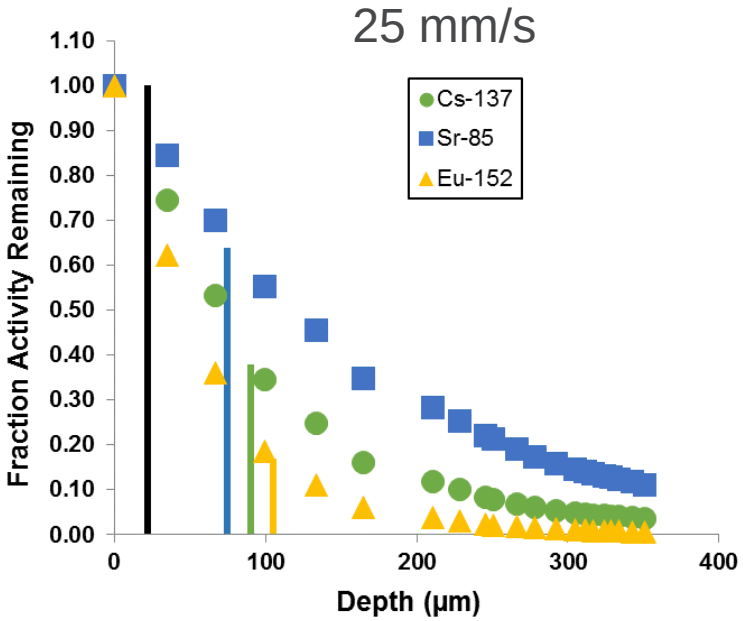
- Coupons were dried and weighed after HPD
- Depth removed was determined and compared the to depths corresponding to removals of each radionuclide
- Concrete removals beyond ablation were attributed to the loss of light, small grains of sand or cement binder

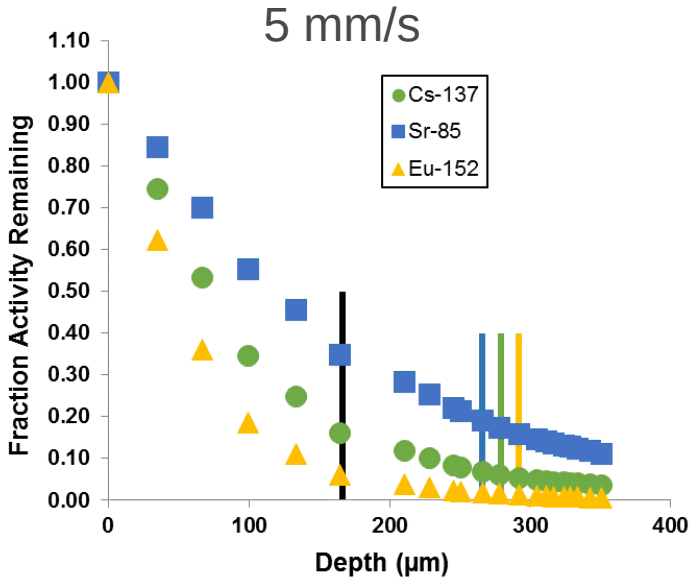


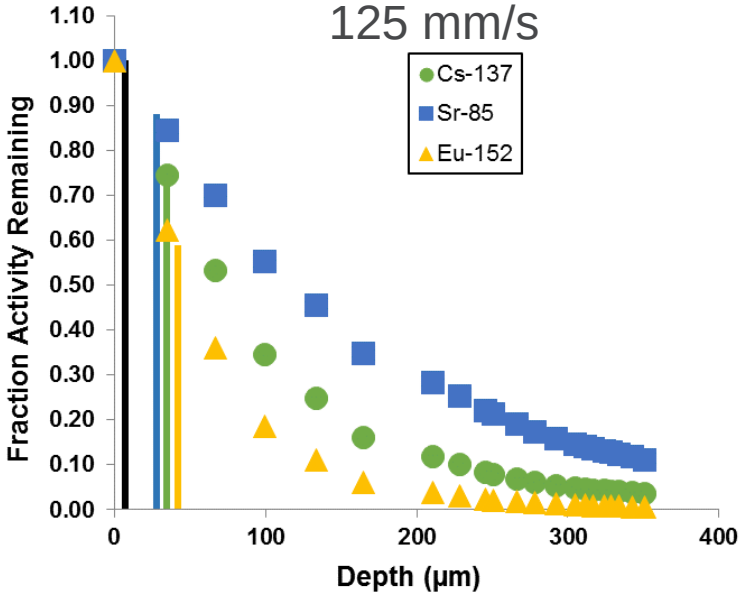
REMOVAL MECHANISMS

Various speeds





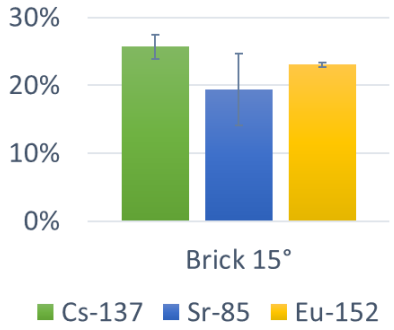


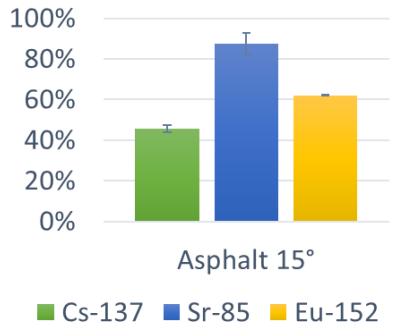


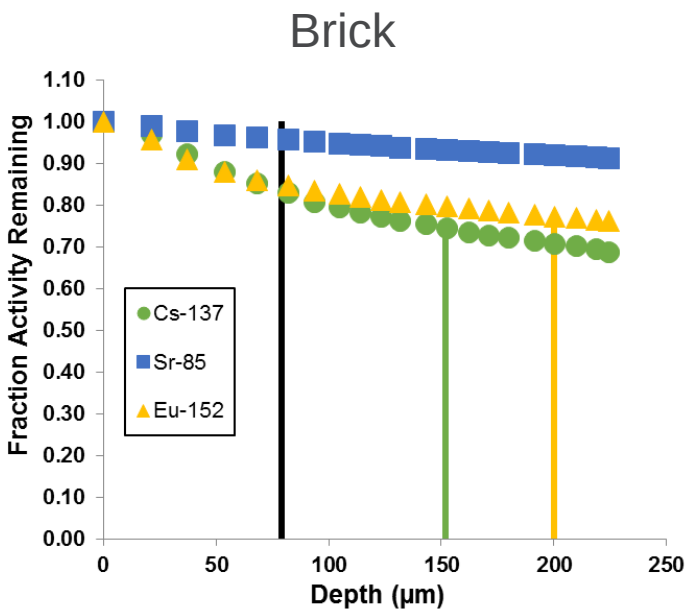
REMOVAL MECHANISMS

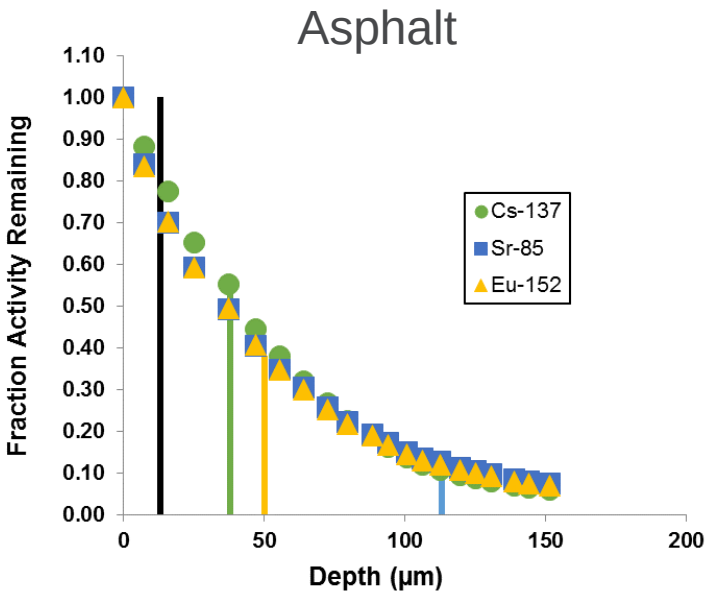
Brick & Asphalt

- For brick and asphalt additional chemical removal of strontium is evident
- Cesium and europium could either be small grain ablation or chemical removal





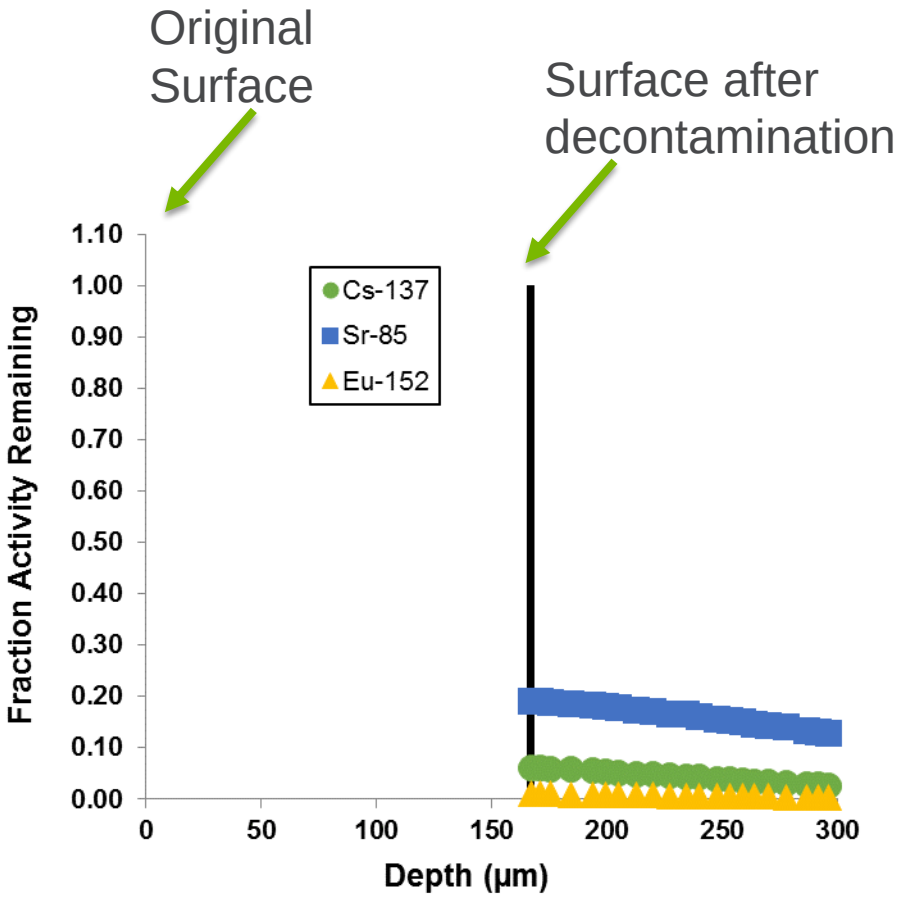




WHAT'S LEFT?

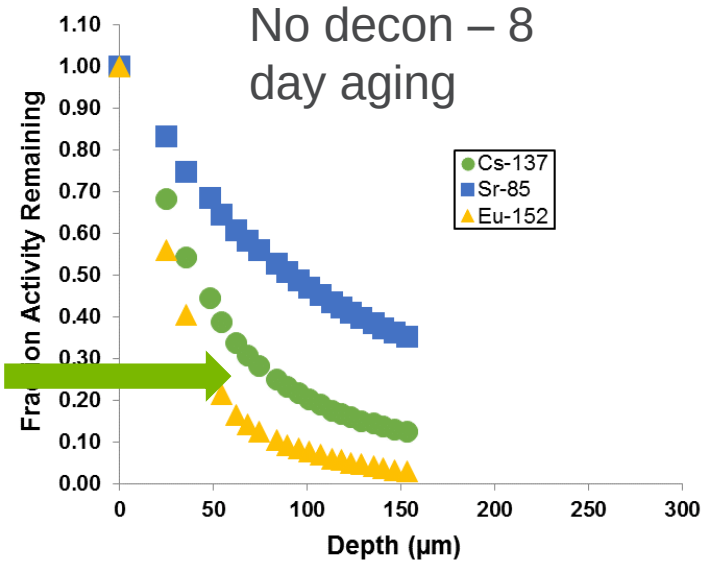
Grind profile in decontaminated concrete coupons

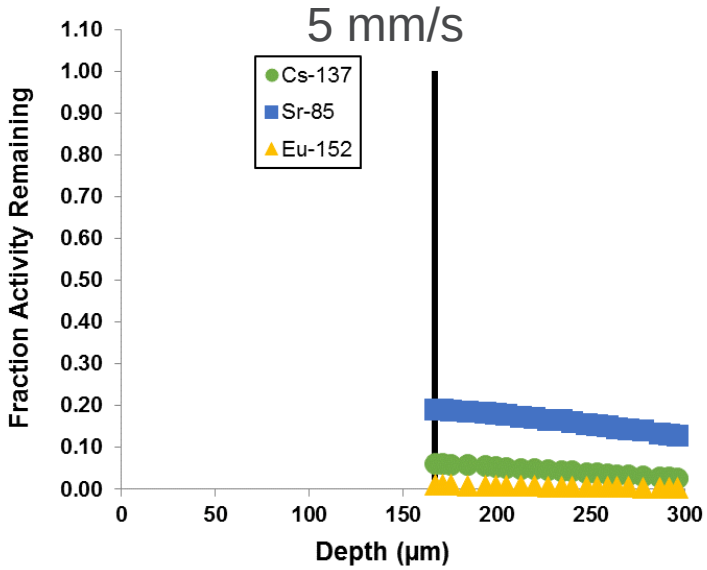
- Coupons were allowed to sit on a benchtop for 1 week after decontamination
- Profiles were created incorporating removals of radionuclides and depth ablated
- If the profiles are similar to non decontaminated coupons: surface ablation dominant removal mechanis
- Differences indicate chemical removals or other processes are involved
- Important for "Final Decontamination

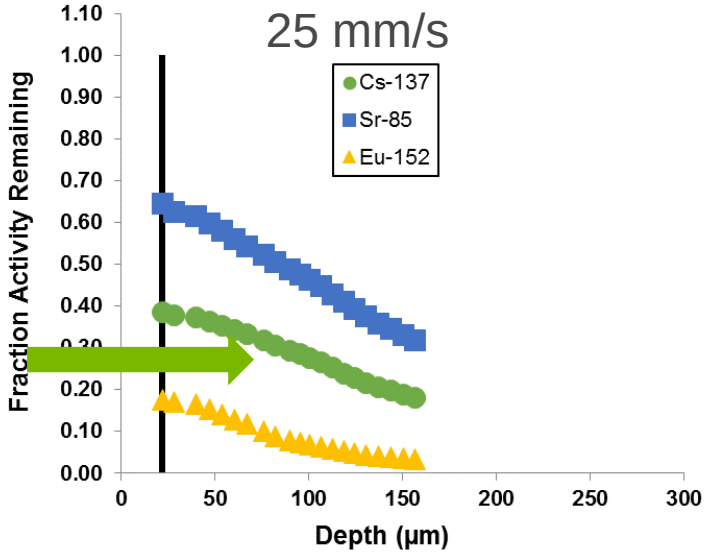


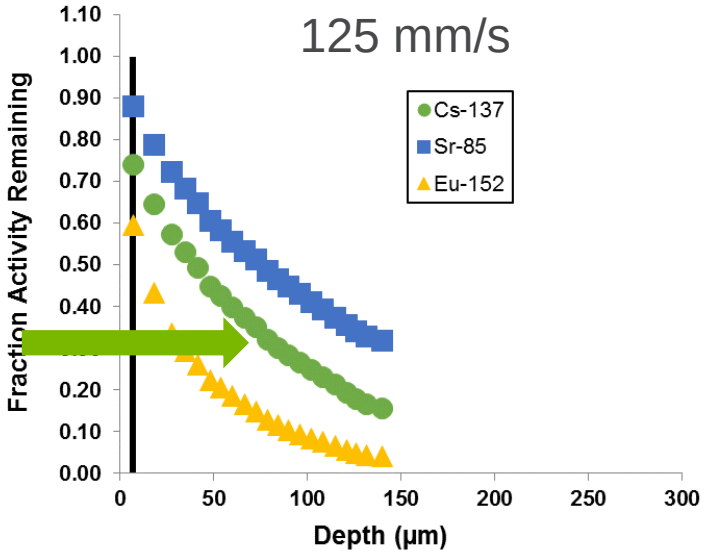
GRIND PROFILE IN DECONTAMINATED COUPONS

Concrete coupons with varied contact time





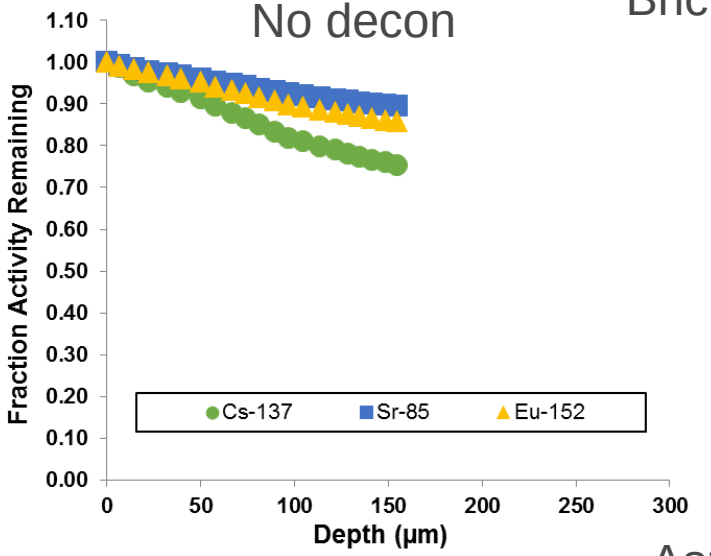


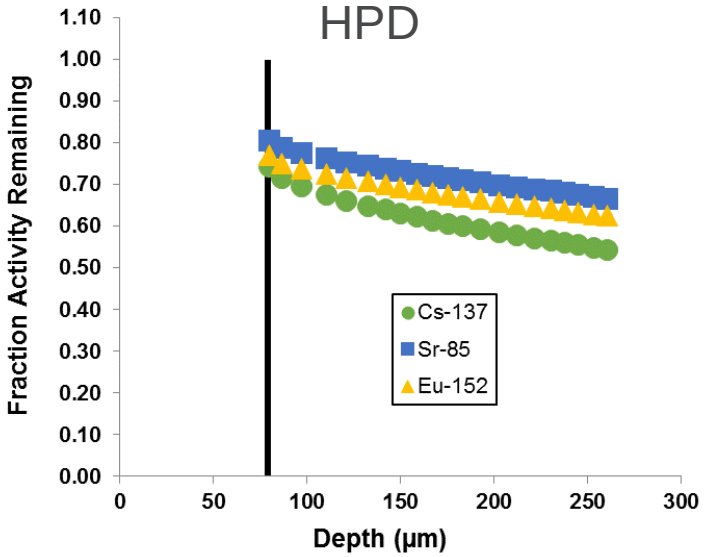


DEPTH PROFILE IN DECONTAMINATED COUPONS

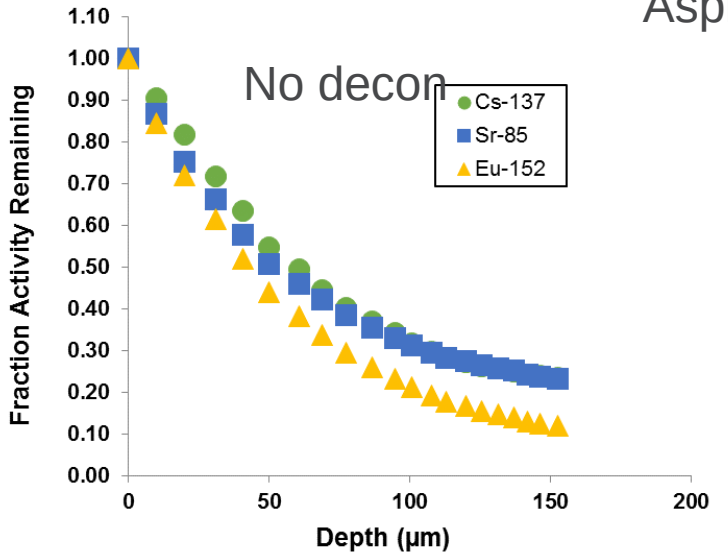
Brick & Asphalt

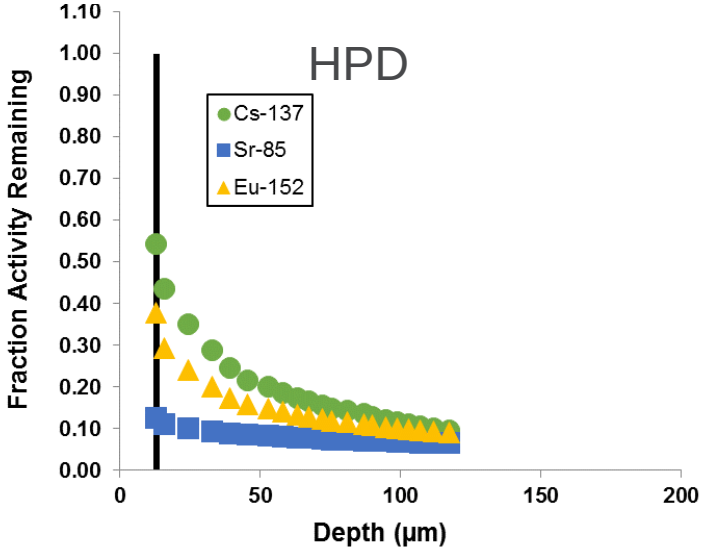
Brick





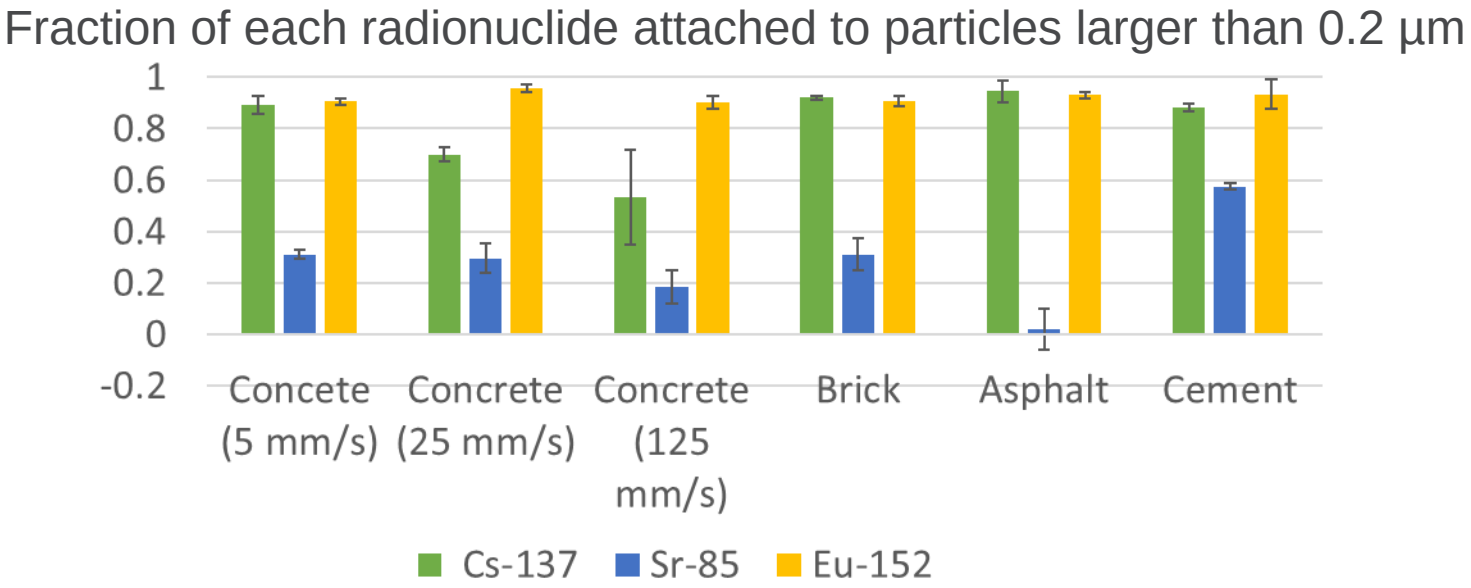
Asphalt





COMPARING RADIONUCLIDE FRACTIONATION IN WASTEWATER

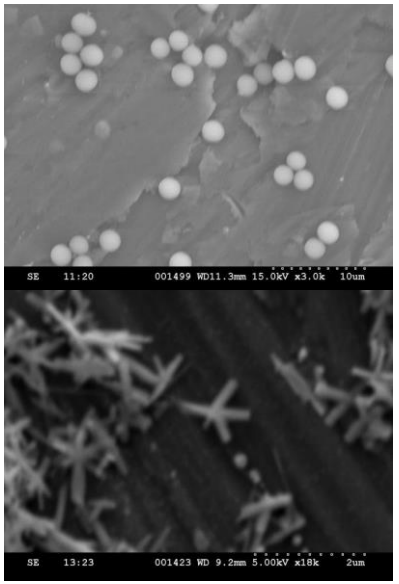
- Treatment possibilities are determined by fractionation
- Fractionation can be caused by either removal mechanism or speciation after removal
- Strontium is dissolved in the waste: chemical removal and dissolution
- Cesium and europium are attached to particulate: ablation and sorption
- Cesium percentages change with speed: more chemical removal or less particle production



CONCLUSIONS AND FUTURE DIRECTIONS

Conclusions and Impact

- Removal mechanisms help establish a plan of attack: “bang for your dose”
- Cesium and europium generally require ablation; strontium may only need to be “washed”
- Too fast of washing may lead to residuals left in surfaces

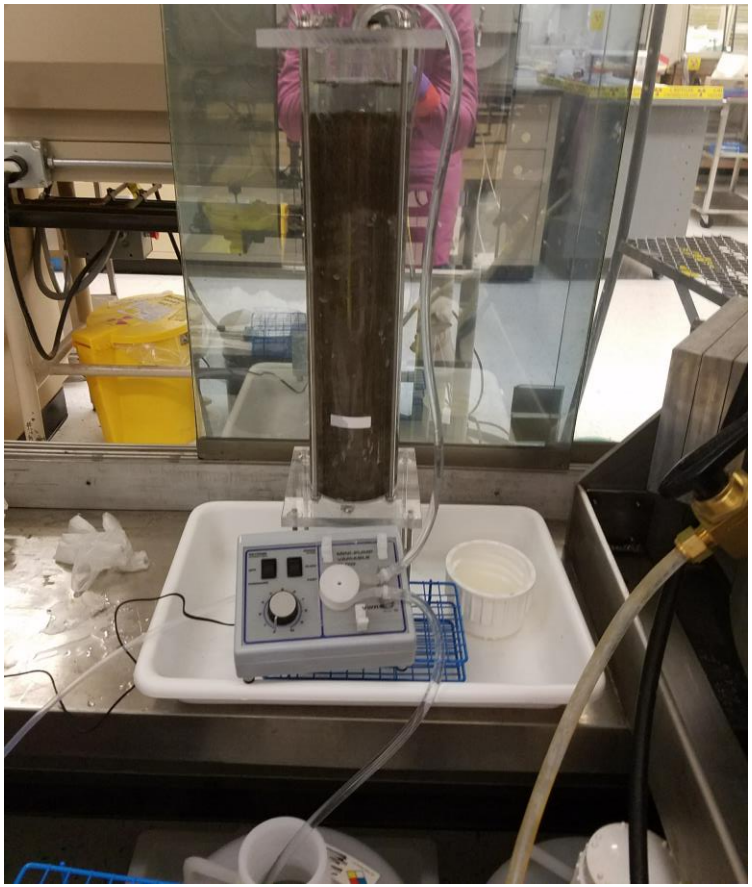


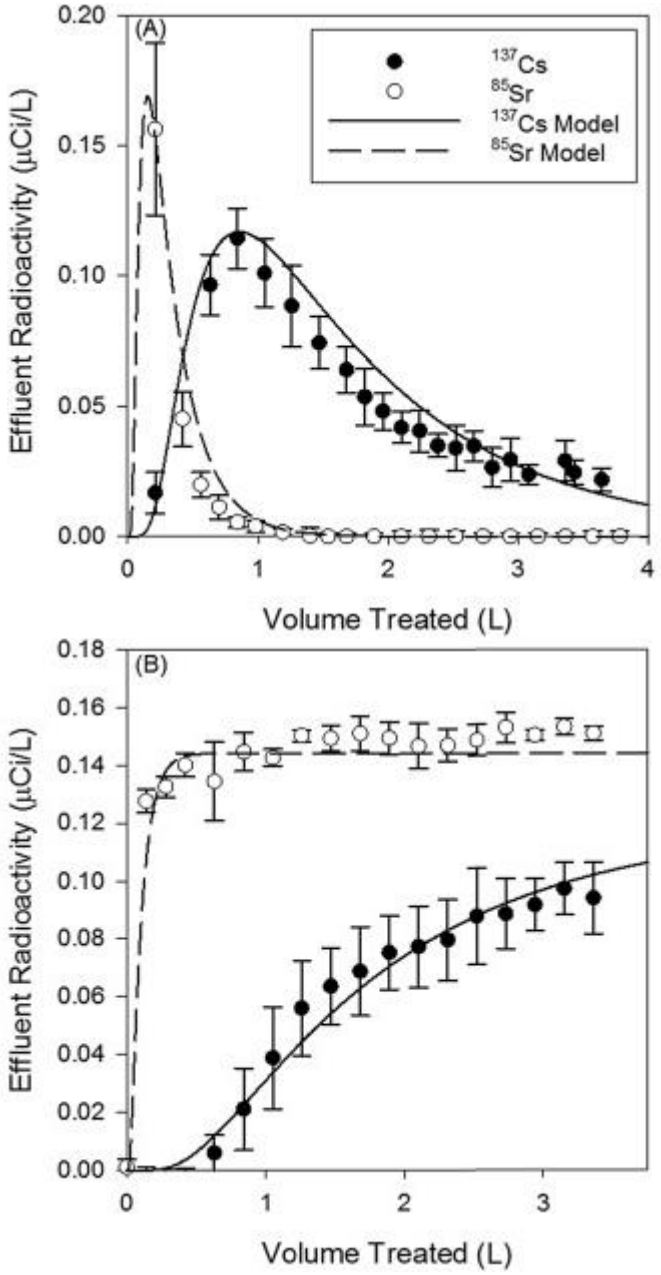
Future Directions

- Radioactive particulates
- Sequestering dissolved strontium: soils and minerals
- Temperatures and salt content
- Continue to study the effects of lower and higher pressures
- Correlate those pressures for those capable with specialty ultra high pressure systems, off the shelf pressure washers, and in street sweepers.

Questions?

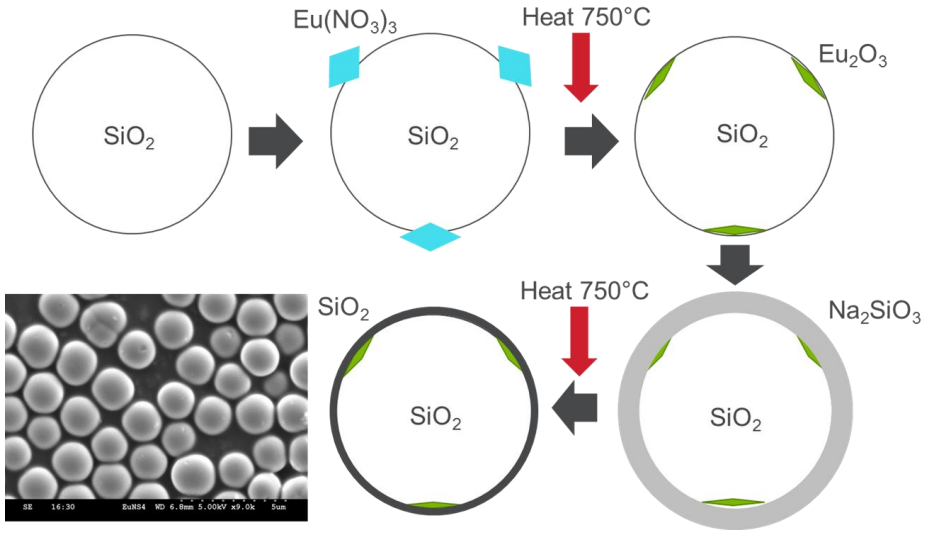
WHAT ABOUT ALL THAT WATER?





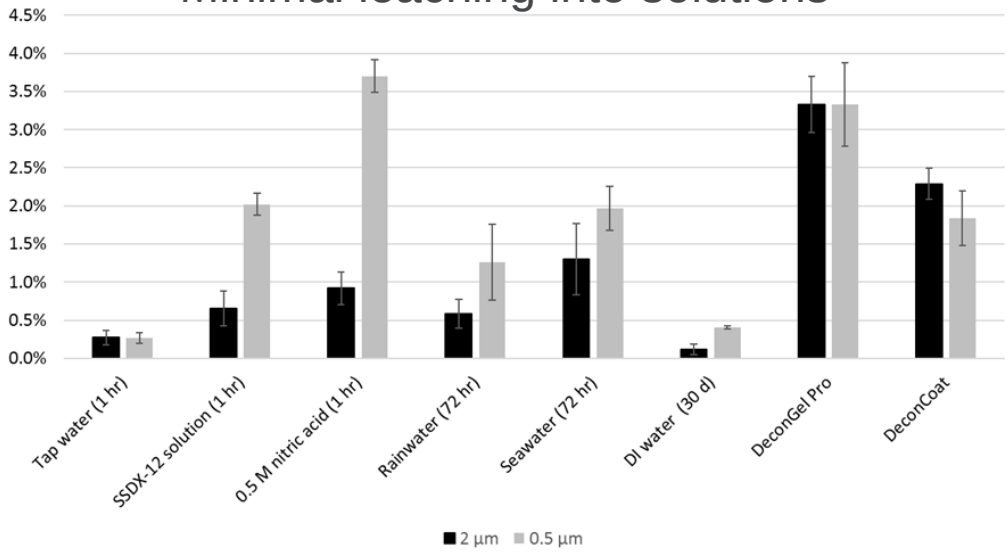
(Jolin and Kaminski 2016)

DEVELOPMENT OF FAR-FIELD FALLOUT SURROGATES



Silicate radiolabeling method

Minimal leaching into solutions



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