Large Area Mitigation using a Water-based Formulation for Rapid Response after a Radiological Incident

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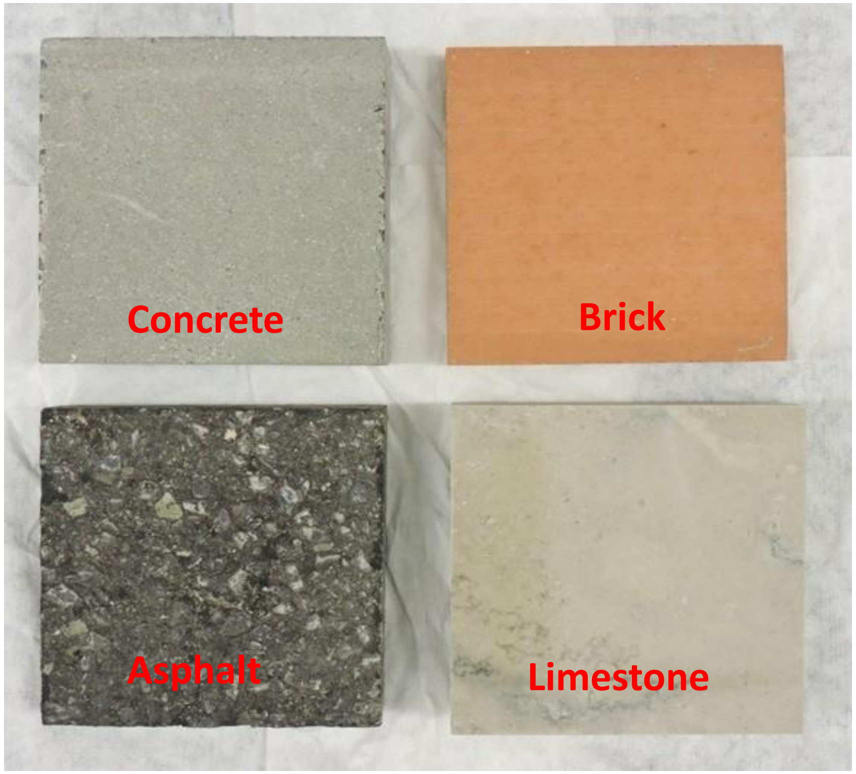
Background

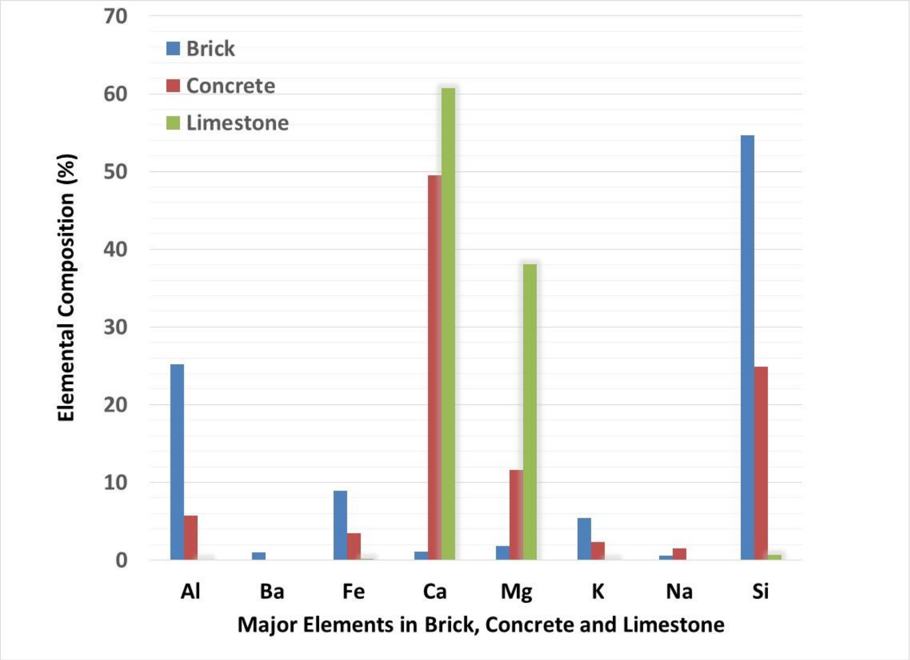
- Significant interest in mitigation and decontamination of critical infrastructure contaminated in a radiological nuclear incident:
  - Accidental (Chernobyl, Fukushima Daiichi)
  - Intentional releases (Radiological Dispersal Device, Improvised Nuclear Device)
- After an incident, effective decontamination processes of evacuated areas such as residential houses, hospitals, schools, forests, roads, parking lots, etc., are needed
- Low-tech processes for removal of contamination from variety of materials:
  - Effective under variety of climate conditions
  - Easily scalable
  - Rapidly deployable
  - Cost effective
  - Commercially available
  - Non-destructive
  - Environmentally friendly

Objective

- In mid-2015, preparations for tests at Chalk River Laboratories to evaluate the effectiveness of a chemical formulation developed at the Environment and Climate Change Canada initiated.
- The study consisted of two phases:
  - **Phase 1:** Assess removal of ^{60}Co, ^{85}Sr, ^{137}Cs and ^{241}Am from the surfaces of concrete, limestone, brick and asphalt (coupon dimensions 6”x 6”x2”)
  - **Phase 2:** Assess removal of ^{60}Co and ^{137}Cs from concrete patio stone and asphalt (coupon dimensions 24”x24”x1”)

Test Materials for Phase 1





All coupons were 6"x 6"x 2" in dimension, except the brick coupons which were 6"x 6"x 1.2"

Temporary Ventilated Enclosures (TVEs) and the Test Stands

Vertical test stands (6.2’x 4.6’) for holding test coupons

Large TVE on the left-hand side (25’ x 12’ x 7.9’) for tests while the smaller TVE on the right-hand side (15’x 7.9’ x 6.9’) was used as change room and points of entry and exit

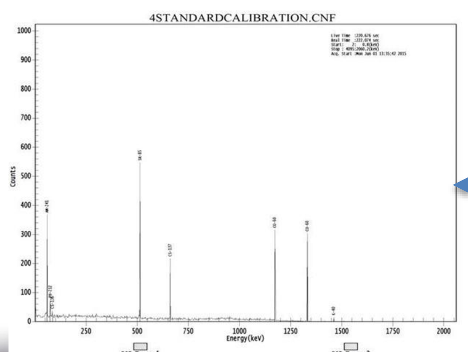
Sequence of Decontamination Steps in Phase 1

Radionuclide delivery system

Radionuclide deposition on coupon surfaces

In-situ recording of the gamma-spectrum

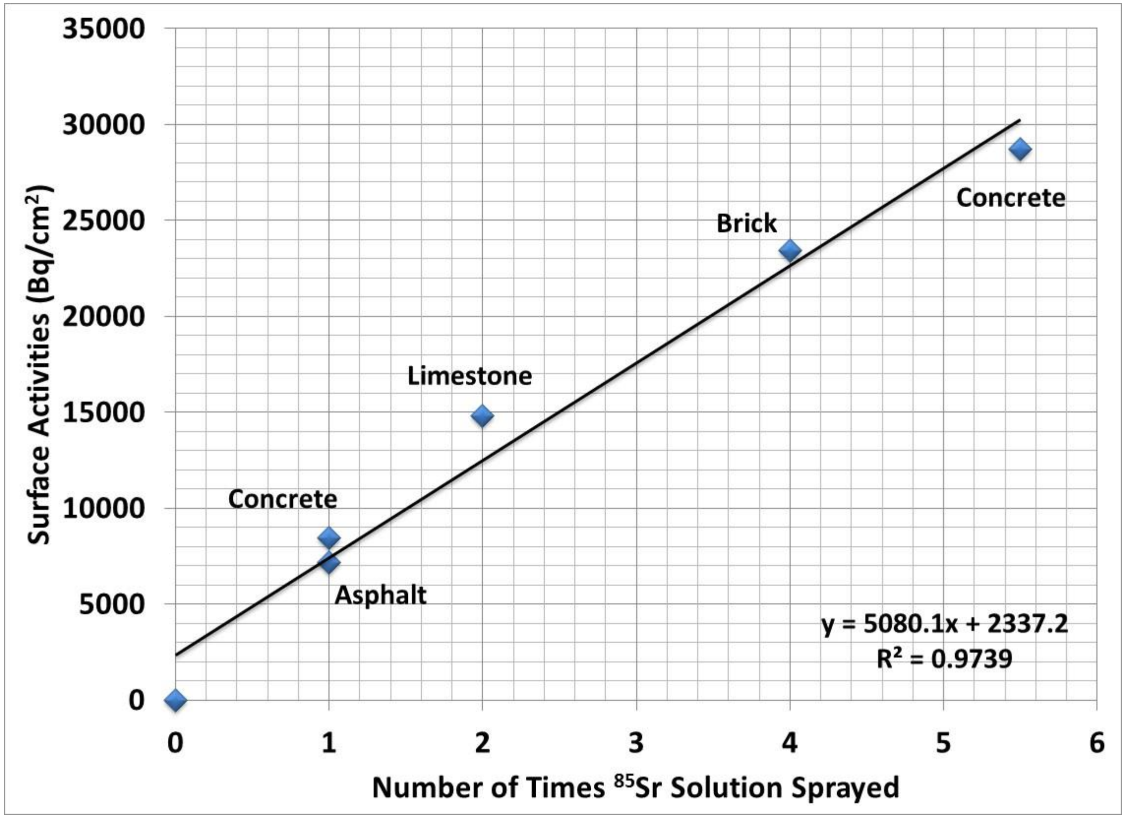
Coupon decontamination and rinse



Gamma-spectroscopy to determine activity removed

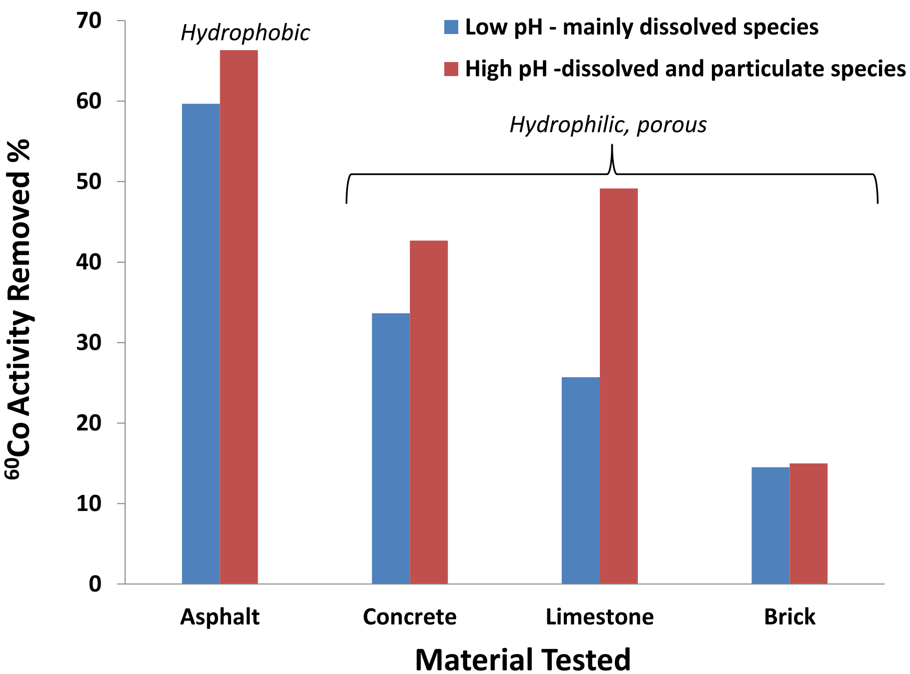
Phase 1 Results – Effect of Radionuclide Concentration on Surface Activities

- Determine if measured surface activities (Bq/cm^2) correspond to concentration of radionuclide sprayed
- ^{60}Co, ^{85}Sr and ^{137}Cs tested on different materials
- Good correlation between concentration and surface activities was obtained for all radionuclides tested

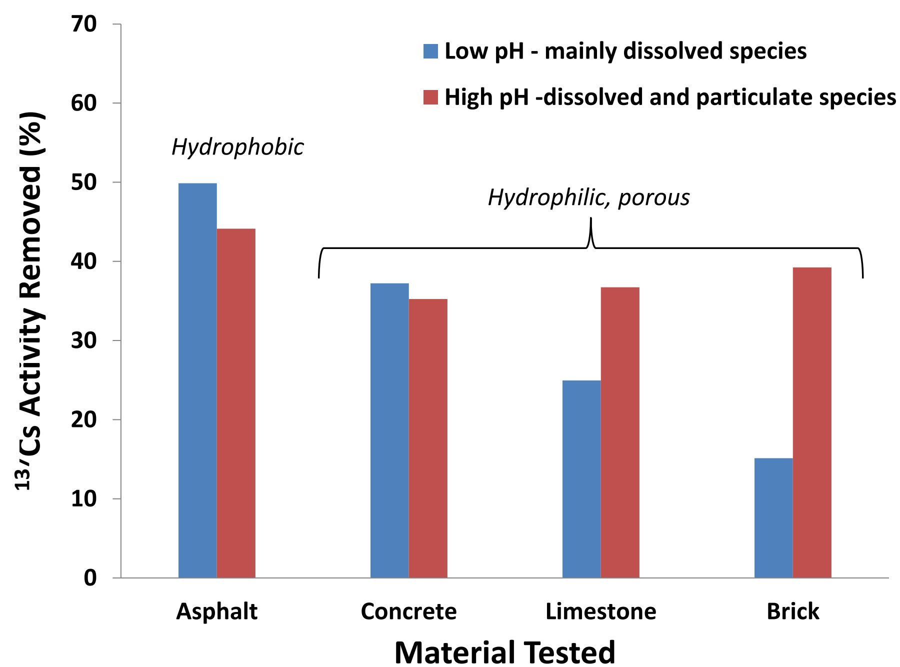


Phase 1 Results – Effect of Coupon Composition and Radionuclide Solution pH on Process Effectiveness

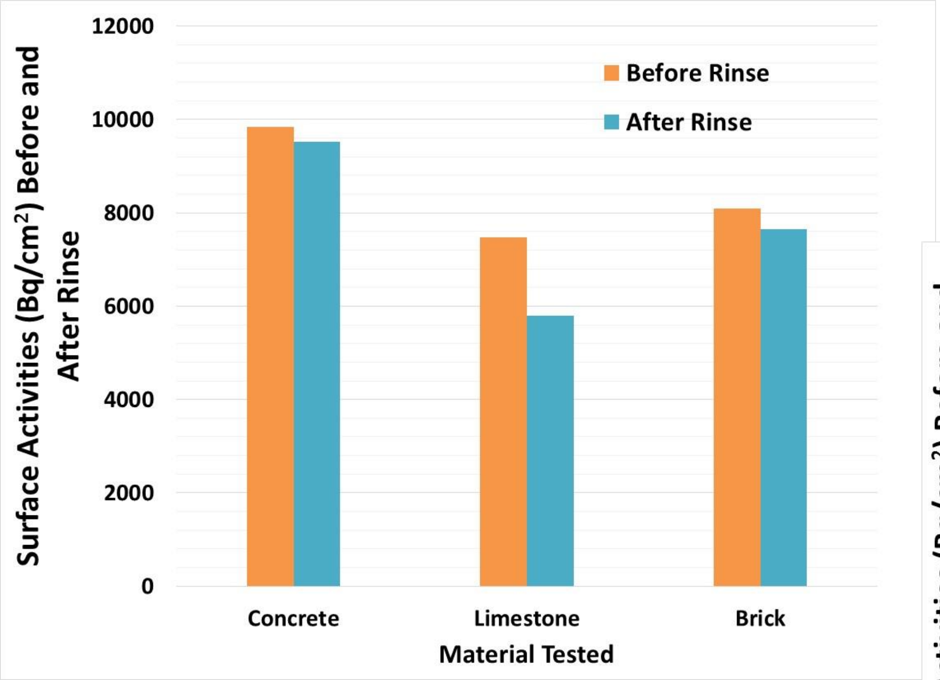
For ^{60}Co, low pH was 1 and high pH was 6.81



For ^{137}Cs, low pH was 0.3 and high pH was 5.31

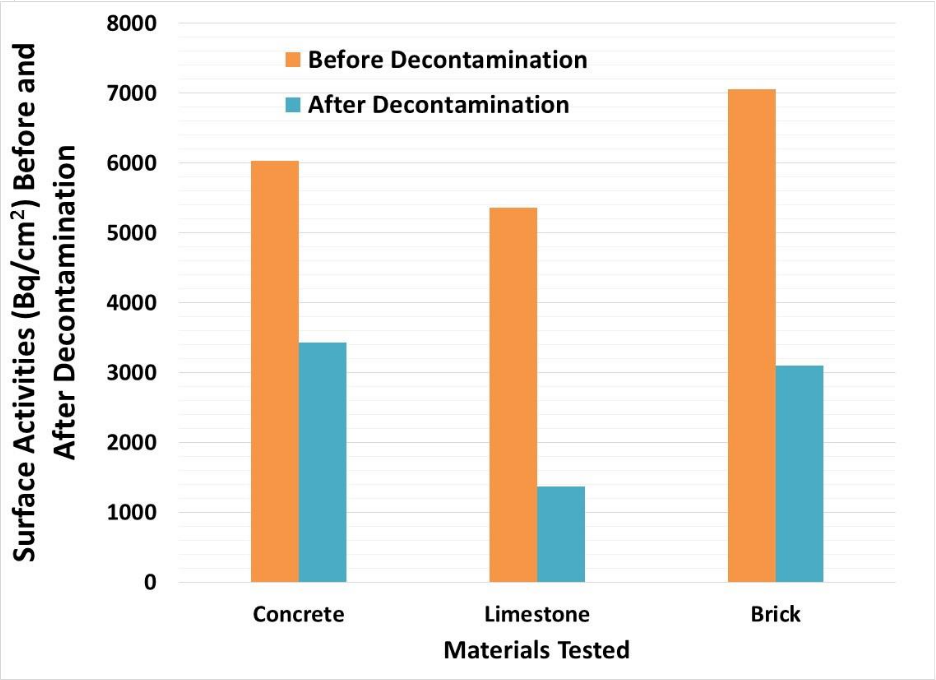


Phase 1 Results - ^{241}Am Activity Removed using Deionized Water and Chemical Formulation

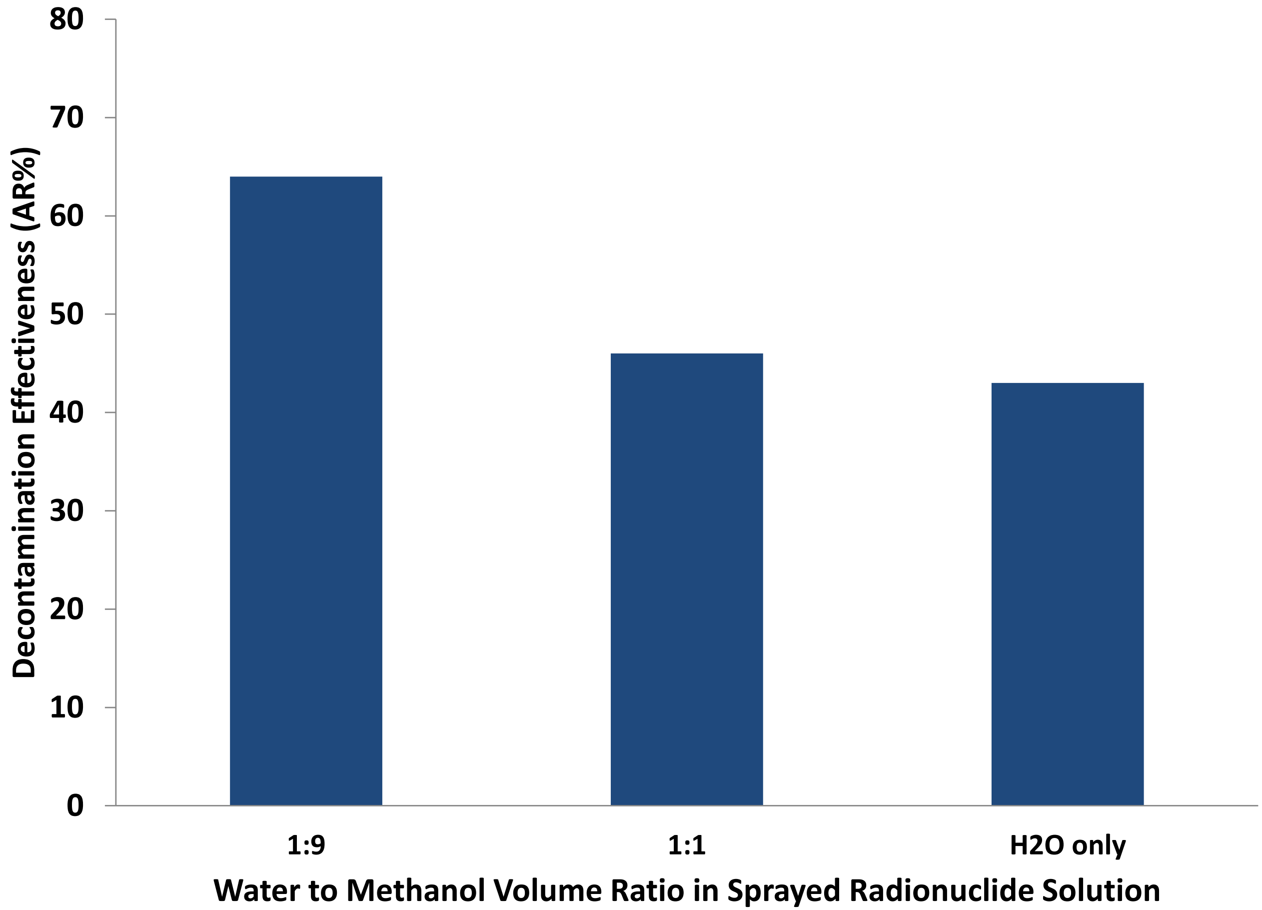


ARs% removed were:

- 75% limestone
- 56% brick
- 43% concrete

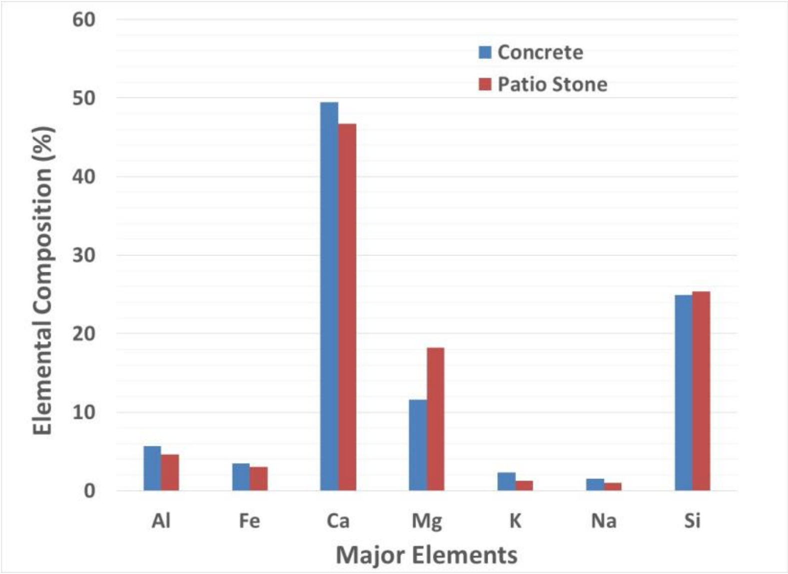


Phase 1 Results –Effect of Methanol on ^{60}Co Removal from Concrete Surfaces



Test Materials for Phase 2

Parking Lot Asphalt



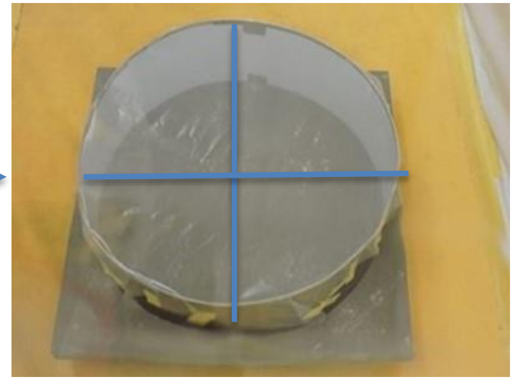
Concrete Patio Stone

Note different surface textures

Concrete

Sequence of Decontamination Steps in Phase 2

Radionuclide delivery system

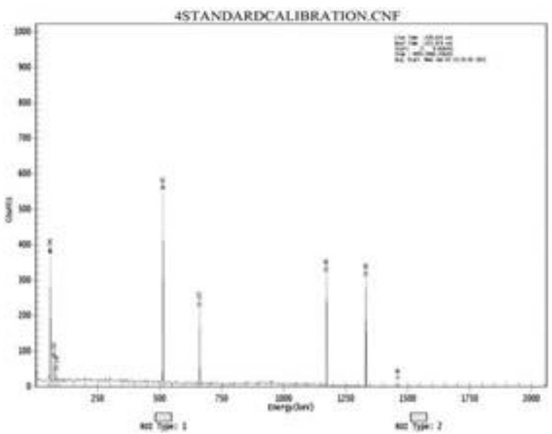


Large coupon surfaces contained before radionuclide deposition

Radionuclide deposition on coupon surfaces

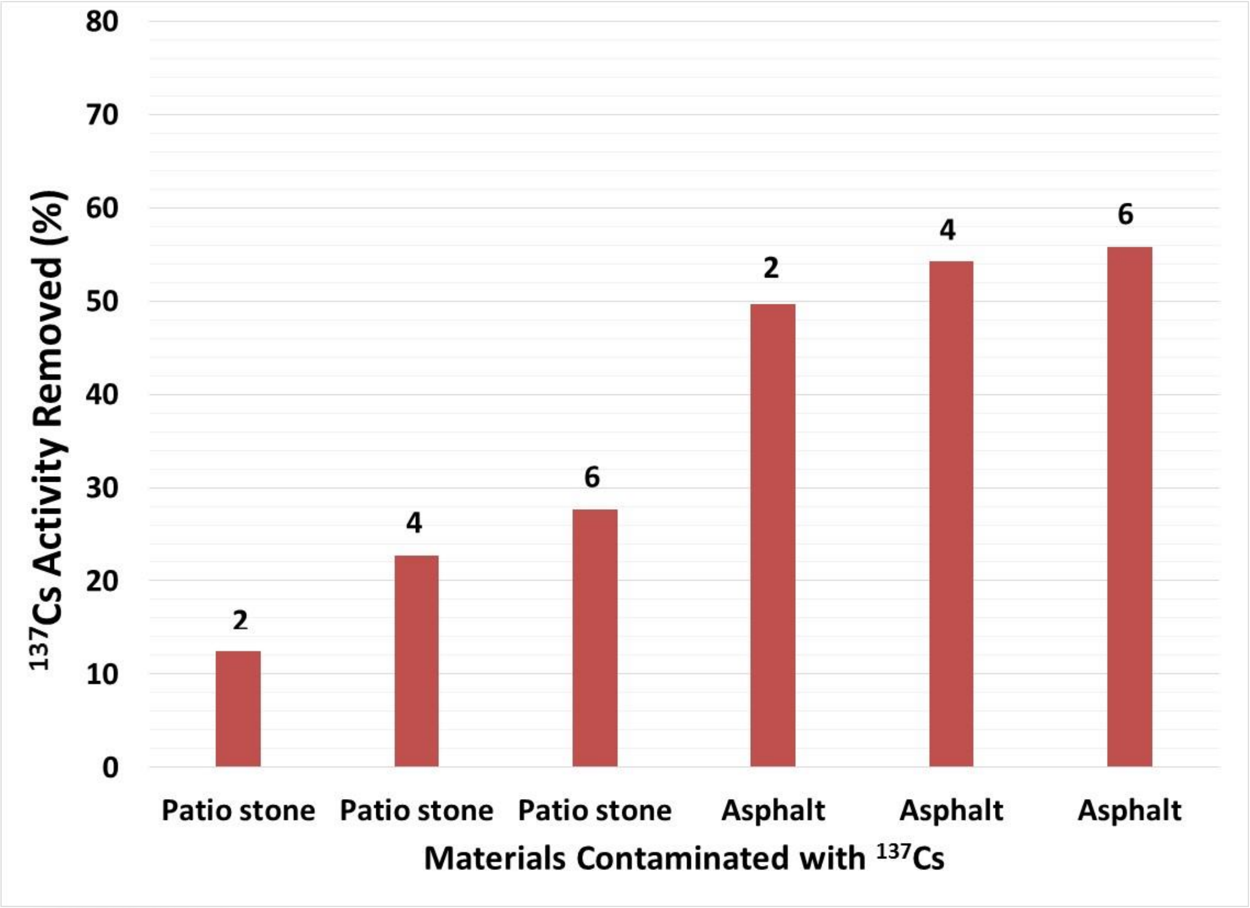
Modified carpet cleaner mimicking street cleaner

Carpet cleaner in use

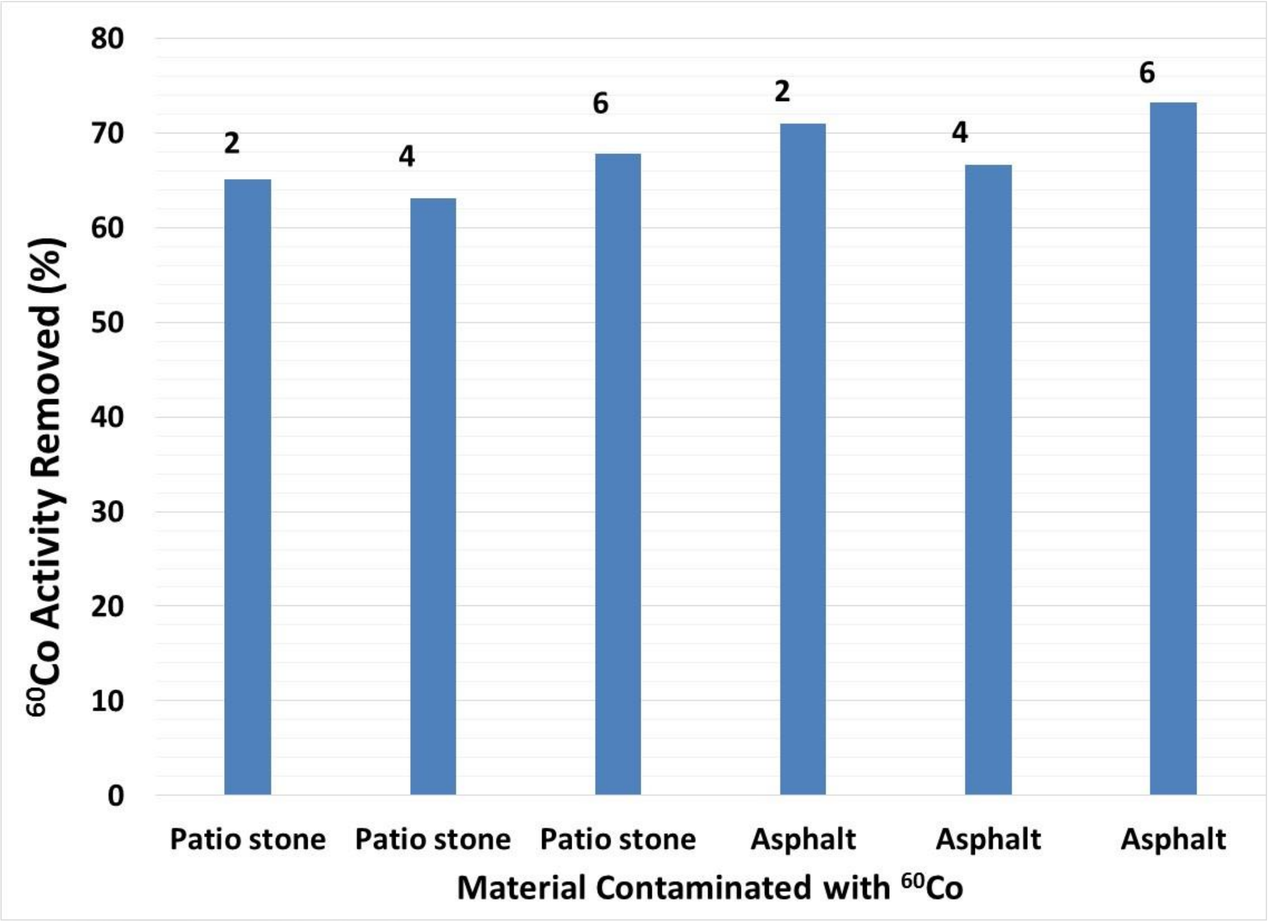


Gamma-spectroscopy to determine activity removed

Phase 2 Results – ^{137}Cs Removal from Patio Stone and Asphalt Surfaces using Multiple Applications – Number of applications above each bar

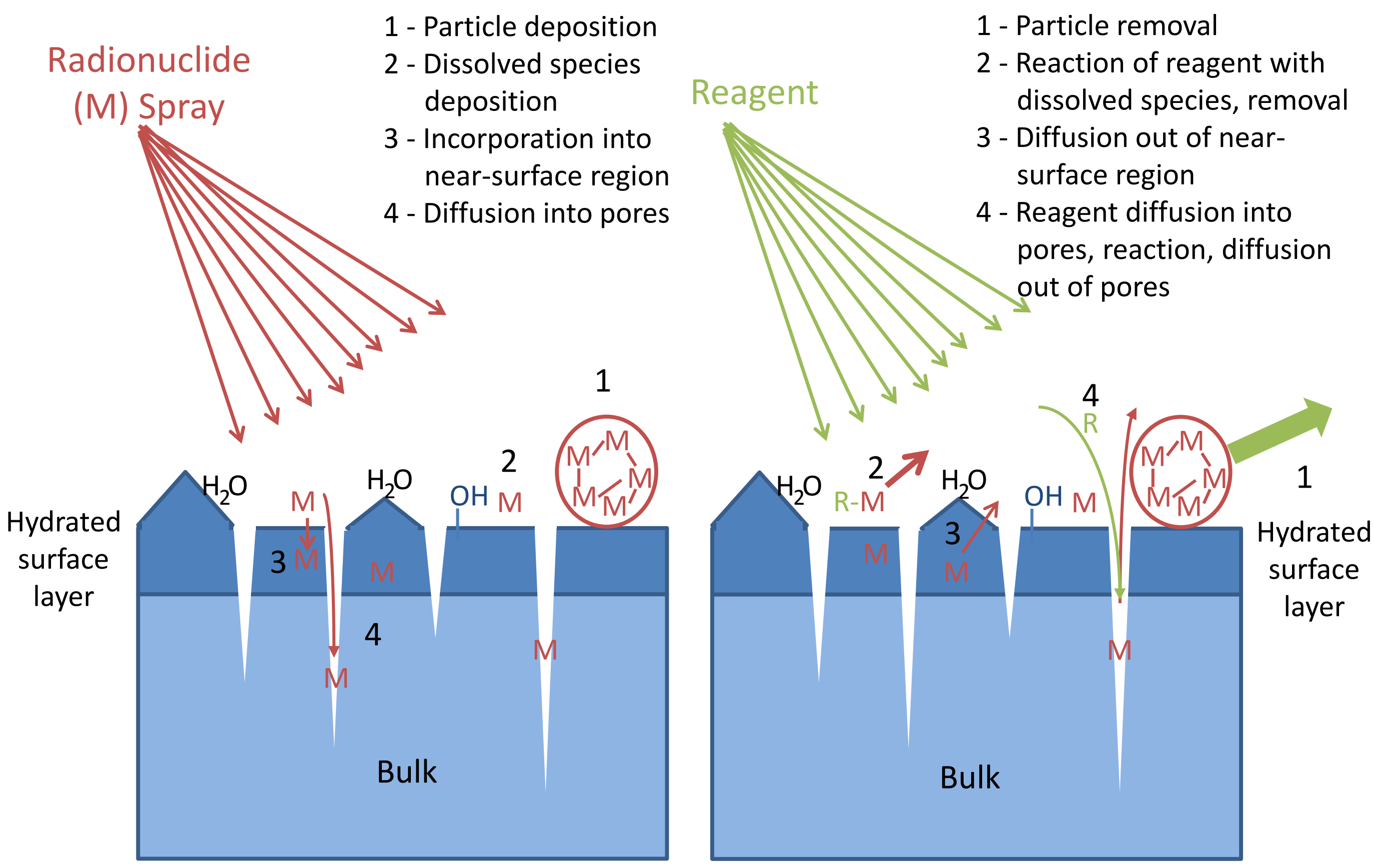


Phase 2 Results – ^{60}Co Removal using Multiple Applications – Number of application above each bar



Schematic Depicting Processes Found to Affect AR%

DEPOSITION **DECONTAMINATION**



Factors affecting decontamination effectiveness:

- Radionuclide chemical and physical properties
- Physical and chemical properties of substrate surface
- Post-contamination history
- Chemistry of decontamination solution

Conclusions

- Phase 1: Identified effect of substrate properties and pH of radionuclide solution as the two most important parameters affecting decontamination effectiveness.
  - Asphalt coupons contaminated with ^{60}Co, ^{85}Sr and ^{137}Cs easiest to decontaminate because of asphalt hydrophobicity
  - Surfaces of concrete, limestone and brick are hydrophilic, porous and alkaline making them more challenging to decontaminate
  - Surface roughness affects large-scale decontamination effectiveness
  - pH affects speciation of radionuclides and substrate surface

- Phase 2: Application of chemical formulation without dwell time, scrubbing or wiping is a promising technique for wide area or large scale decontamination.

Acknowledgements

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