Fate and Transport of Cesium RDD Contamination – Implications for Cleanup Operations

INTRODUCTION

A radiological dispersal device (RDD) is used to spread radiological contamination to do harm. A dirty bomb is an RDD that uses a conventional explosive device for dispersal. The EPA would likely be involved with remediation of areas contaminated after an RDD incident. In support of its customers, the EPA's Homeland Security Research Program (HSRP) is assessing strategies and methodologies for remediation of areas contaminated due to RDDs. Initial research efforts have focused on cesium (Cs), an extremely mobile and difficult to clean up radionuclide. To inform cleanup and sampling strategies, EPA's National Homeland Security Research Center has conducted a series of studies focused on assessing how cesium travels into and adheres to urban materials as a function of relative humidity and precipitation.

Summary Points

Study Materials: asphalt, brick, concrete, limestone, and granite

Cs penetrates 0.2 to 3.5 mm in 28 days depending on material type and RH.

Of the study materials, it penetrates furthest in granite and concrete.

For concrete, limestone and brick the maximum degree of sorption was seen after 24 hours of interaction, while for asphalt and granite it occurred after 6 days.

Weathering, as simulated rain, was observed to remove Cs from the materials.

The overall removal was dependent upon the material type with the highest percent removed observed for asphalt.

CESIUM INTERACTIONS WITH URBAN SURFACES UNDER TYPICAL AMBIENT CONDITIONS

Cesium chloride (CsCl), even if it is deposited as a dry particle, will eventually become aqueous when exposed to relative humidities (RH) above 67% or to rain. Cs containing aqueous droplets can easily be transported through the pores of porous materials or through surface cracks. Once Cs ions (Cs hereafter) have migrated into these materials, Cs can be difficult to efficiently extract without removal of the affected surface. The adsorption of the Cs to the porous materials also hampers its ability to be extracted using existing chemically based decontamination technologies.

The ability to remove Cs from surfaces depends on the ability to reach the contamination. This ability is partially governed by the penetration depth. To experimentally assess the migration of Cs in its aqueous form into urban materials, water solutions of Cs were aerosolized onto the surfaces of five study materials: asphalt, brick, concrete, limestone, and granite. The migration was determined by measuring Cs penetration depths as a function of high and low RH. Results from the 87% RH experiments are shown in the table.

From these studies, it was concluded that the Cs penetration depth profile primarily depends on the type of building material and heterogeneity of the sample surface. These studies also demonstrate that the penetration depth was not strongly affected by the contaminant-surface interaction time for up to 28 days; operationally this would be the time between contamination and cleanup. The ability to remove Cs from these surfaces also depends on the ability to desorb the Cs from the material or to extract the Cs before it develops strong binding to the material. This ability is partially governed by the Cs adsorption. The Cs sorption characteristics were determined by spiking water solutions of Cs onto the urban surfaces. These studies showed that sorption of Cs increased with time (from 1 to 28 days) for the five study materials studied. The maximum degree of sorption was seen after 24 hours of interaction for concrete, limestone and brick, while for asphalt and granite it occurred after 6 days. These sorption test results also suggested that asphalt is the material with the highest sorption capability. Lastly, to assess the properties to desorb the Cs, the ability to extract Cs with competing ions was tested. This extraction ability increased in the following order: brick > granite > limestone > concrete > asphalt.

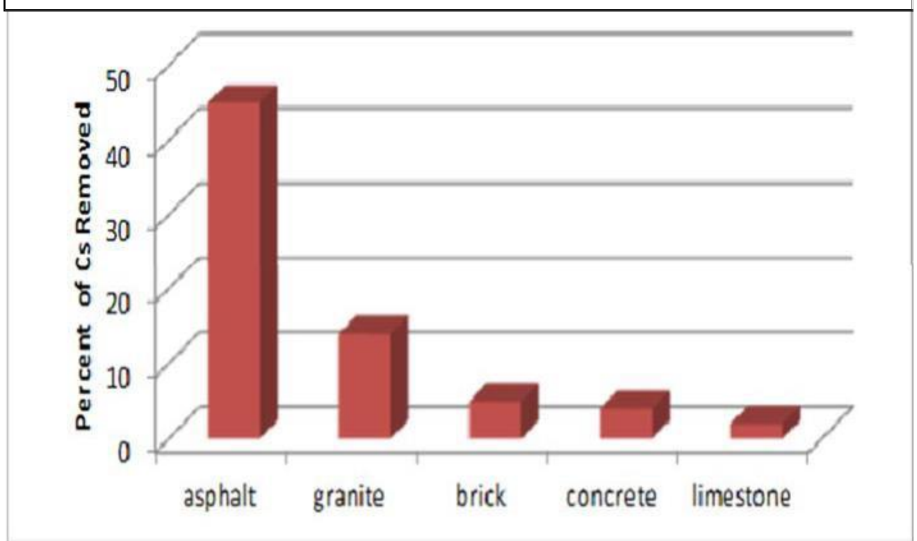
Contaminant-Surface Interaction Time (days)	Penetration Depth* (mm) 87% Relative Humidity				
	Asphalt	Limestone	Granite	Concrete	Brick
1	0.2	0.7	2.0	0.5	0.8
7	0.4	1.7	0.2	0.7	0.8
14	0.4	1.3	3.5	0.5	0.7
28	0.6	1.4	2.3	2.6	1.1

Data extracted from Gusarov et al.i and Maslova et al.ii.
*Penetration depths (mm) indicate where 90 % of the cesium was found

EFFECT OF WEATHERING ON CS CONTAMINATED SURFACES

It is known that weathering can reduce the contamination on surfaces. To assess the impacts of weathering process on Cs contamination, the amount of Cs removed from urban surfaces (asphalt, brick, concrete, limestone, and granite) and the amount of Cs penetrated into the building materials after a simulated rain event (average 2 cm per hour for 30 min) was determined. The coupons were contaminated by spiking them with water solutions of Cs. The percent of Cs removed is shown in Figure 1 iii. The penetration depth of Cs into the building materials was in the following order: limestone > brick > concrete = asphalt = granite. These results suggest that that it would be more difficult to remove Cs from some materials such as brick, concrete, and limestone after a rain event than prior to the event due to greater subsurface penetration.

Figure 1: Percent of initial Cs contamination removed from study materials after simulated rainfall (2 cm/hr) [iii].



CONTACT INFORMATION

For more information, visit the EPA Web site (www.epa.gov/nhsrc).

Technical Contact: SangDonLee (lee.sangdon@epa.gov)

General Feedback/Questions: KathyNickel (nickel.kathy@epa.gov)

If you have difficulty accessing this PDF document, please contact Kathy Nickel (Nickel.Kathy@epa.gov) or Amelia McCall (McCall.Amelia@epa.gov) for assistance.

REFERENCES

i A. Gusarov, N. Il'icheva, A. Konoplev, S.D. Lee, K. Maslova, V. Popov and I. Stepina. Fate and Transport of radiocesium in urban building materials. International Conference on Radioecology & Environmental Radioactivity: Environment & Nuclear Renaissance. 2011, 46(6): S265-S269.

ii Maslova, K., et al., Fate and transport of radiocesium, radiostrontium and radiocobalt on urban building materials, Journal of Environmental Radioactivity. 2013, 125: 74-80. (http://dx.doi.org/10.1016/j.jenvrad.2013.01.013).

iii U.S. Environmental Protection Agency. Fate of Radiological Dispersal Device (RDD) Material on Urban Surfaces: Impact of Rain on Removal of Cesium, EPA/600/R-12/569, 2012.

U.S. EPA's Homeland Security Research Program (HSRP) develops products based on scientific research and technology evaluations. Our products and expertise are widely used in preventing, preparing for, and recovering from public health and environmental emergencies that arise from terrorist attacks or natural disasters. Our research and products address biological, radiological, or chemical contaminants that could affect indoor areas, outdoor areas, or water infrastructure. HSRP provides these products, technical assistance, and expertise to support EPA's roles and responsibilities under the National Response Framework, statutory requirements, and Homeland Security Presidential Directives.

August 2014
EPA/600/R-14/250