

Persistence of Simulated Radionuclides on Drinking Water Pipes

Ryan James, Battelle

Jeff Szabo, EPA National Homeland Security Research Center

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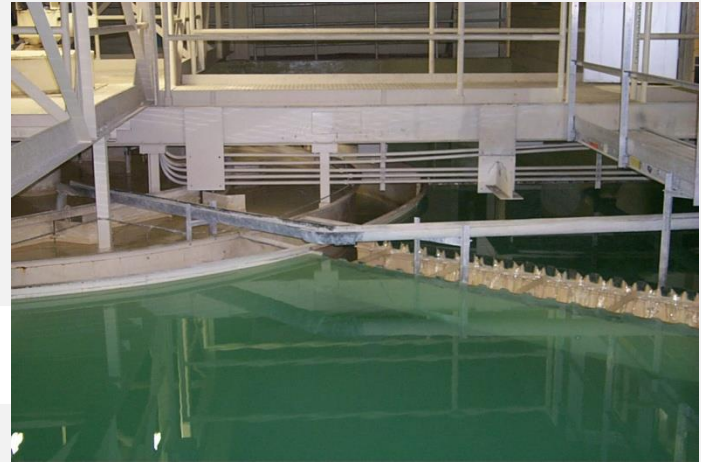
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Water System Decontamination

- Drinking water system decontamination includes
 - Treatment plants
 - Distribution systems
- What decontamination approaches would be used?
- How effective are they?
- What remediation levels need to be achieved?

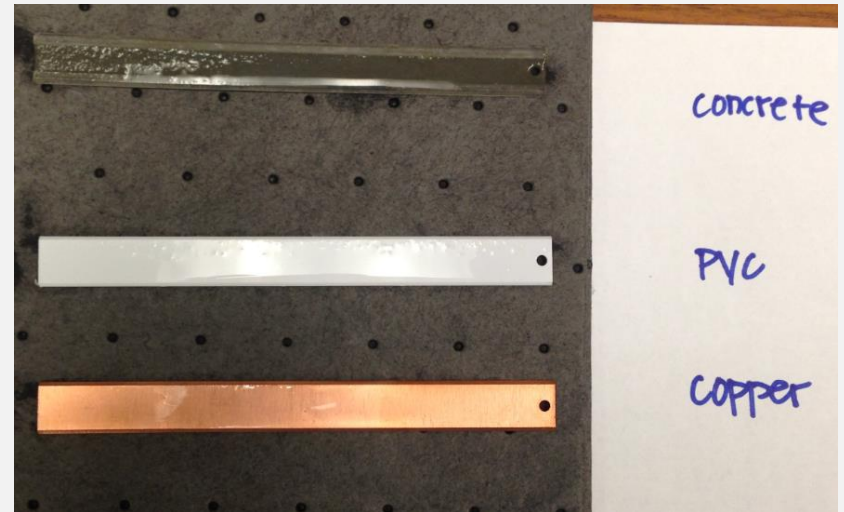


Project Overview

- Testing of the pipe decontamination experimental design with a radiological contaminant
 - Determine adsorption of contaminant to drinking water pipe materials of construction
 - Testing of methods for decontaminating affected pipe surfaces if contaminant persists
 - Testing of the pipe decontamination experimental design with radiological contaminants

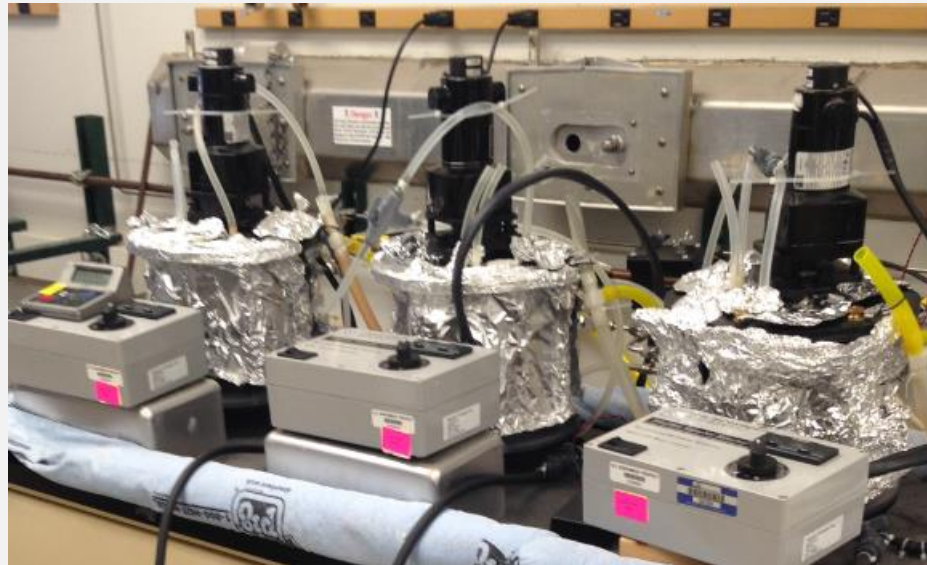
Technical Approach

- Pipe Selection
 - Cement-lined, PVC, and copper annular reactor coupons
- Contaminant
 - Cs-137
- Contamination Method
 - Biofilm growth in dark
 - Equilibration with contaminated solution
- Contaminant Detection Methodology
 - Gamma spectroscopy (NaI_{SS}) and Liquid Scintillation Counting (LSC)



Persistence Evaluation (PE) Experimental Design

- Coupons equilibrated in 1 L of contaminated deionized water for 24 hours
 - 20 coupons per reactor, coupon materials in separate reactors
 - 100 uCi/L Cs-137 for concrete and 10 uCi/L for copper and PVC
 - Annular reactor rotating at 100 rpm with no flow
- Removed 4 coupons as control coupons (2-NaISS, 2-LSC)
- Filled annular reactor (AR) with tap water and resumed rotation at 100 rpm for 24 hours (removed 4 coupons)
- Drained and refilled AR and restarted rotation at 100 RPM and removed 4 coupons for activity measurement after 2, 3, 4, and 5 days



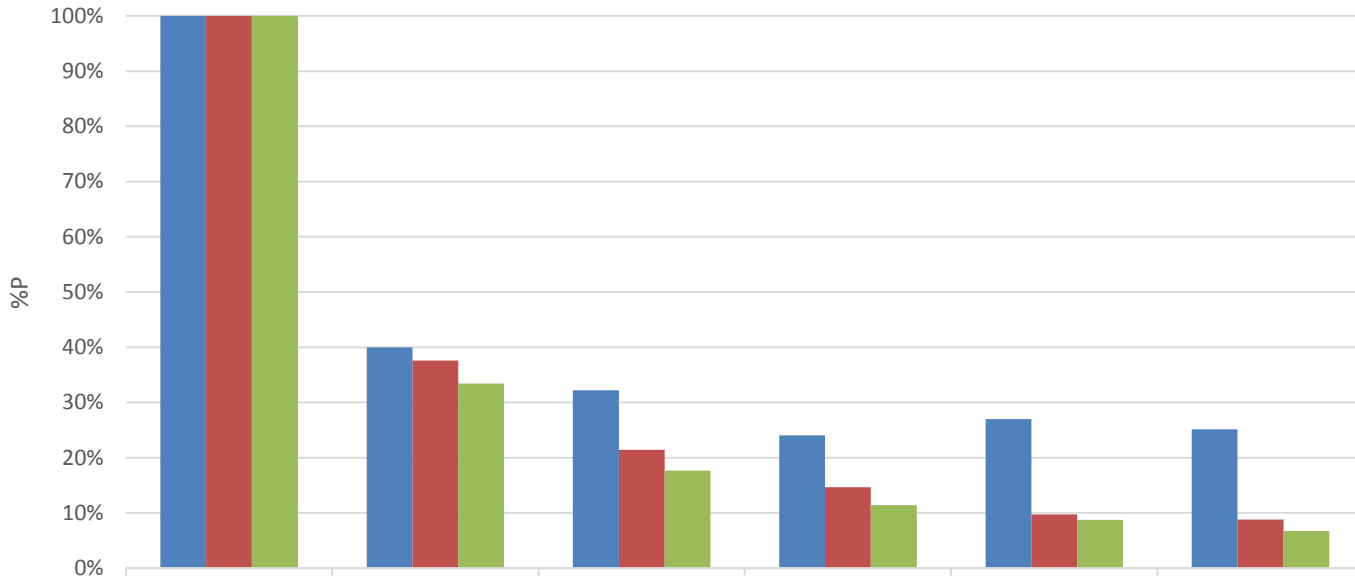
Initial Surface Contamination Results

Analysis Method	Coupons					
	Copper		PVC		Concrete	
NaISS (net counts)	1,870	Cu1	15,364	PVC1	58,233	Con1
	1,793	Cu2	8,838	PVC2	57,057	Con2
LSC (DPM)	5,441	Cu3	36,901	PVC3	221,694	Con3
	4,638	Cu4	46,148	PVC4	180,811	Con4

- Cs-137 adsorbed to concrete the most, followed by PVC and then copper
- Concrete coupon backing was not included in LSC analysis

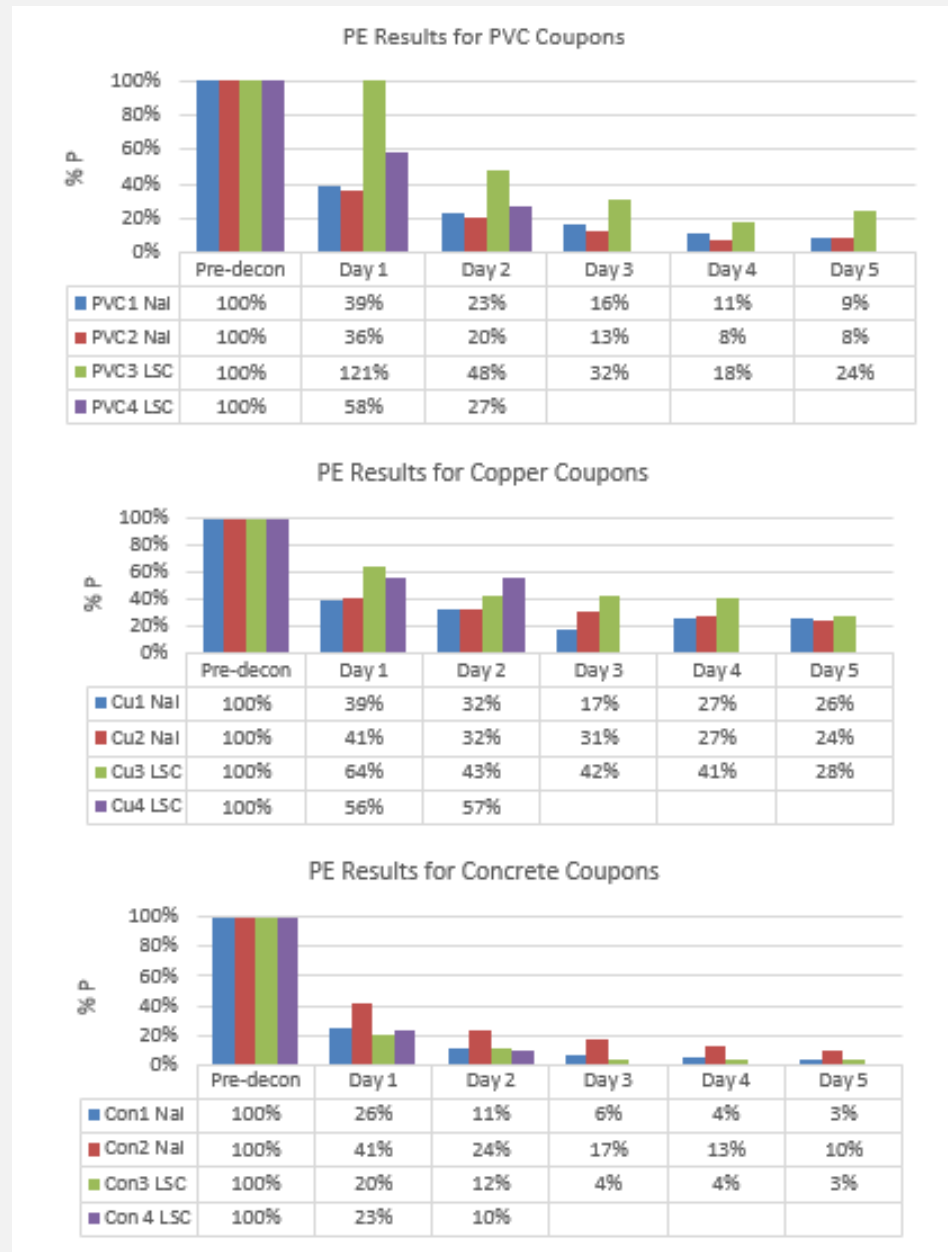
Persistence Evaluation Results

Average % Persistence for Cu, PVC, and Concrete



	Pre-decon	Day 1	Day 2	Day 3	Day 4	Day 5
Cu NaI	100%	40%	32%	24%	27%	25%
PVC NaI	100%	38%	21%	15%	10%	9%
Con NaI	100%	33%	18%	11%	9%	7%

PE Detection Method Results



Chemical Cleaning Agent (CCA) Evaluation Experimental Design

- Conducted after water-only persistence evaluation
- Ammonium Chloride and potassium chloride are the CCAs
- Refill with fresh CCA daily for 4 days and removed coupons for analysis
- Results compared directly to Water Exposure Control Experiment (WECE) results

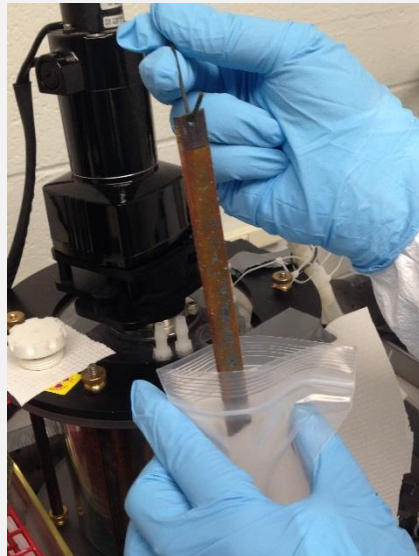
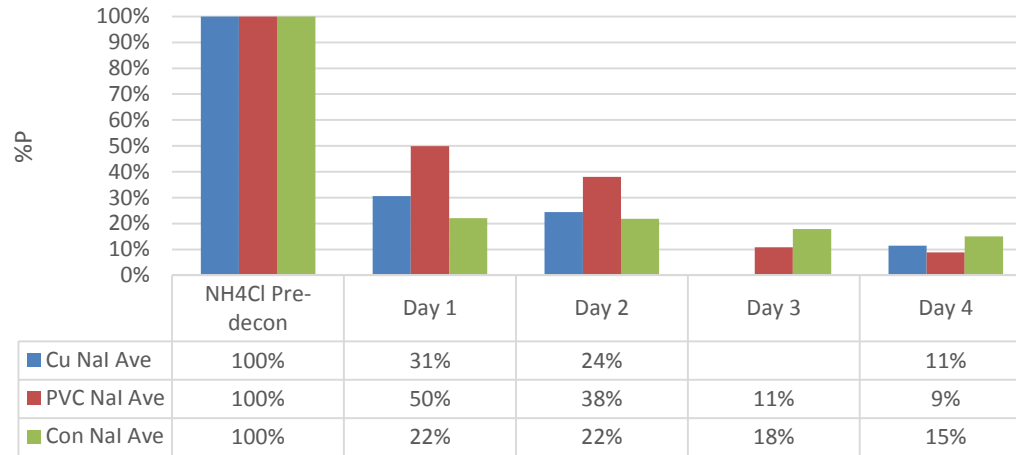
NH₄Cl CCA Contamination Results

Analysis Method	Coupons					
	Copper		PVC		Concrete	
NaISS (net counts)	502	Cu1	1,031	PVC1	1,515	Con1
	444	Cu2	575	PVC2	4,771	Con2
LSC (DPM)	1,725	Cu3	6,446	PVC3	4,103	Con3

Activity on coupons after the Persistence Evaluation

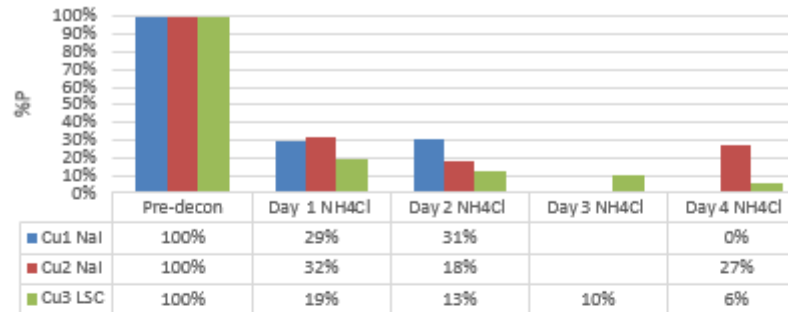
NH₄Cl CCA Evaluation Results

NH₄Cl CCA results for Cu, PVC, and Concrete

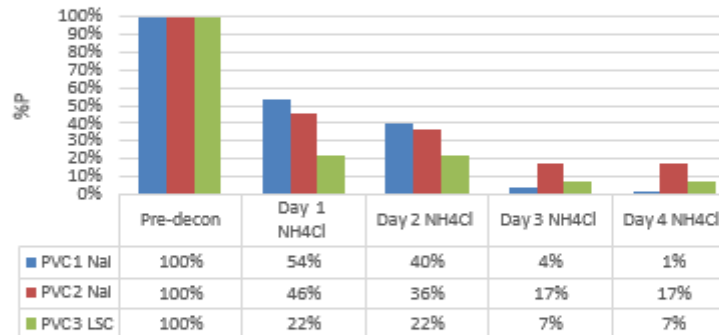


NH₄Cl CCAE Detection Method Results

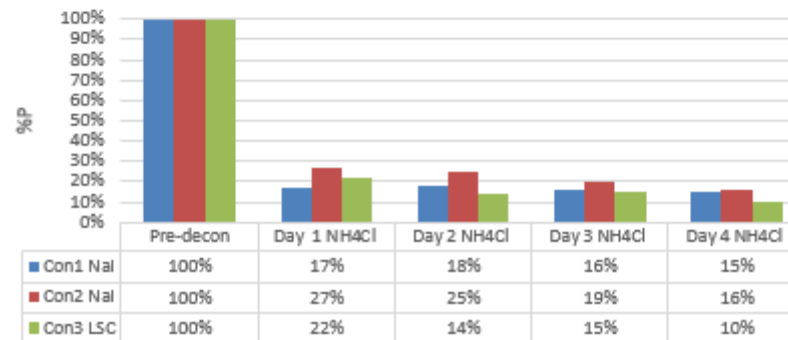
NH₄Cl CCAE Results for Copper Coupons



NH₄Cl CCAE Results for PVC Coupons



NH₄Cl CCAE Results for Concrete Coupons



KCl CCA Contamination Results

Analysis Method	Coupons					
	Copper		PVC		Concrete	
NaISS (net counts)	2,806	Cu1	2,573	PVC1	39,242	Con1
	2,930	Cu2	2,390	PVC2	71,847	Con2
LSC (DPM)	8,458	Cu3	14,984	PVC3	307,417	Con3
	8,947	Cu4	9,149	PVC4	238,010	Con4

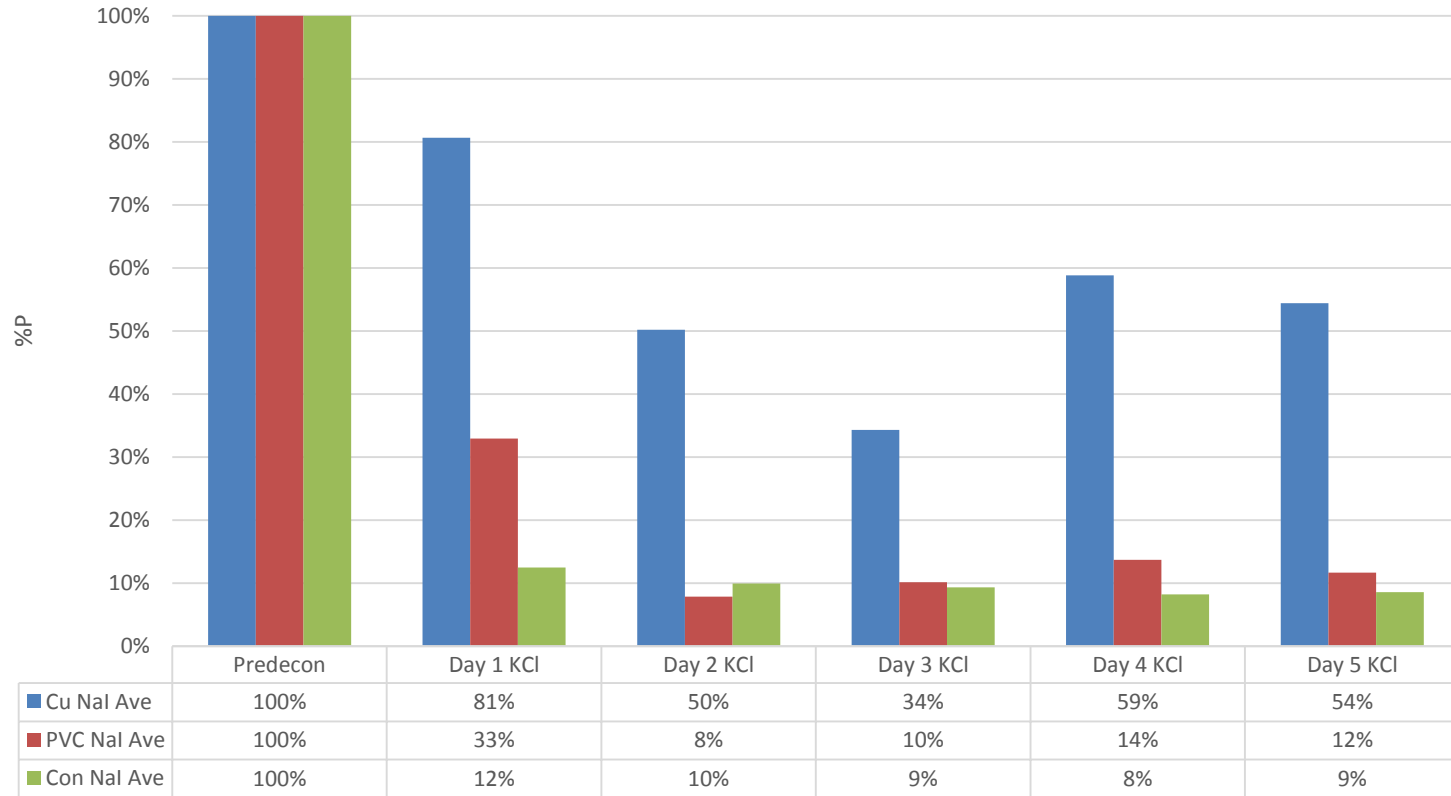
Before water-only decontamination

Analysis Method	Coupons					
	Copper		PVC		Concrete	
NaISS (net counts)	598	Cu1	271	PVC1	9,085	Con1
	562	Cu2	267	PVC2	10,775	Con2
LSC (DPM)	1,171	Cu3	794	PVC3	13,731	Con3
	865	Cu4	1,189	PVC4	39,975	Con4

After water-only decon
(before KCl decon)

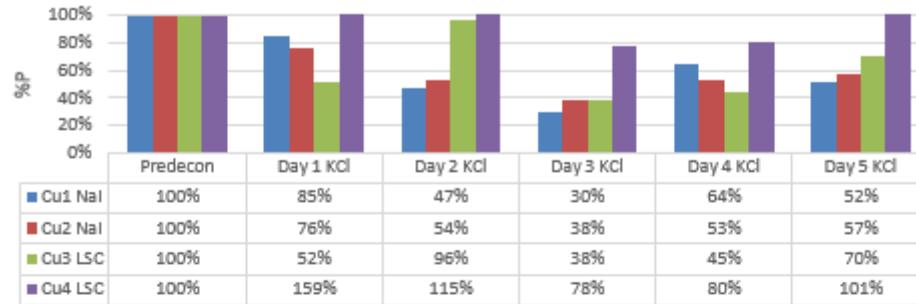
KCI CCA Evaluation Results

KCI CCA results for Cu, PVC, and Concrete

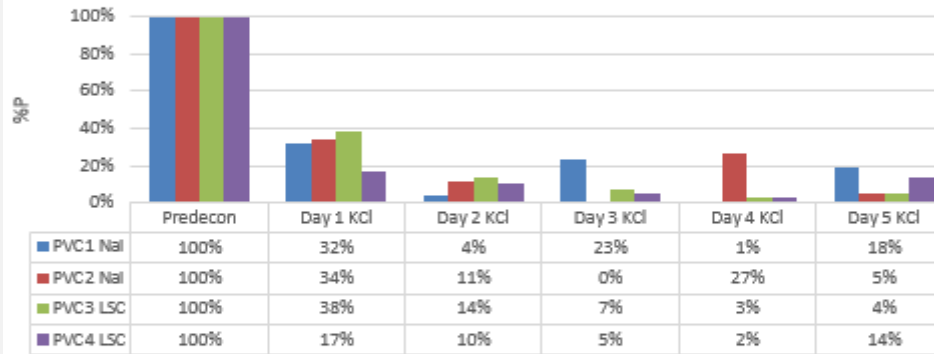


KCI CCA Detection Method Results

KCI CCAE Results for Copper Coupons

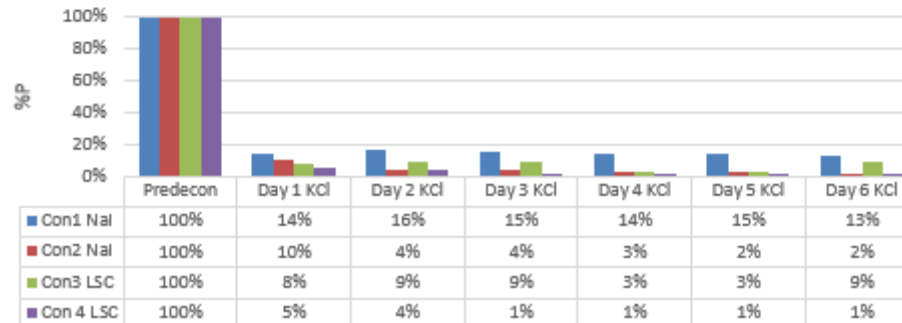


KCI CCAE Results for PVC Coupons



Results after Day 2 are at or below the detection limits of both analytical methods.

KCI CCAE Results for Concrete Coupons



Results Summary

- Flushing with clean drinking water reduced the contamination level about 75% for the copper pipe materials and >90% for the PVC and concrete pipe
- NH₄Cl CCA - results have more variability on the copper coupons, possibly due to a precipitate that formed
- NH₄Cl CCA - Cs-137 from the PVC and concrete piping materials removed to about 9% and 15% remaining after decontamination
- NH₄Cl CCA - detrimental to copper systems, as effective as tap water for PVC pipe materials, and is somewhat less effective for decontamination on the concrete materials
- KCl CCA - copper coupons remained persistent at about 50 %P after five days and no precipitate
- KCl CCA - PVC results show contamination was reduced to the detection limit after 2 days
- KCl CCA - concrete coupons decreased to about 10 % P after 2 days, then remained at Day 2 levels
- KCl CCA - more effective than drinking water flushing and NH₄Cl in decontaminating PVC and concrete pipe materials; contaminant levels were reduced to lower levels in less time for the PVC and concrete coupons

Thank You!

Questions?

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