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NATIONAL HOMELAND SECURITY RESEARCH CENTER

Evaluation of Wipe Sampling Parameters and Surface Analysis of Organophosphorus Pesticide Environmental Samples by LC/MS

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EPA Response to Contamination Incidents

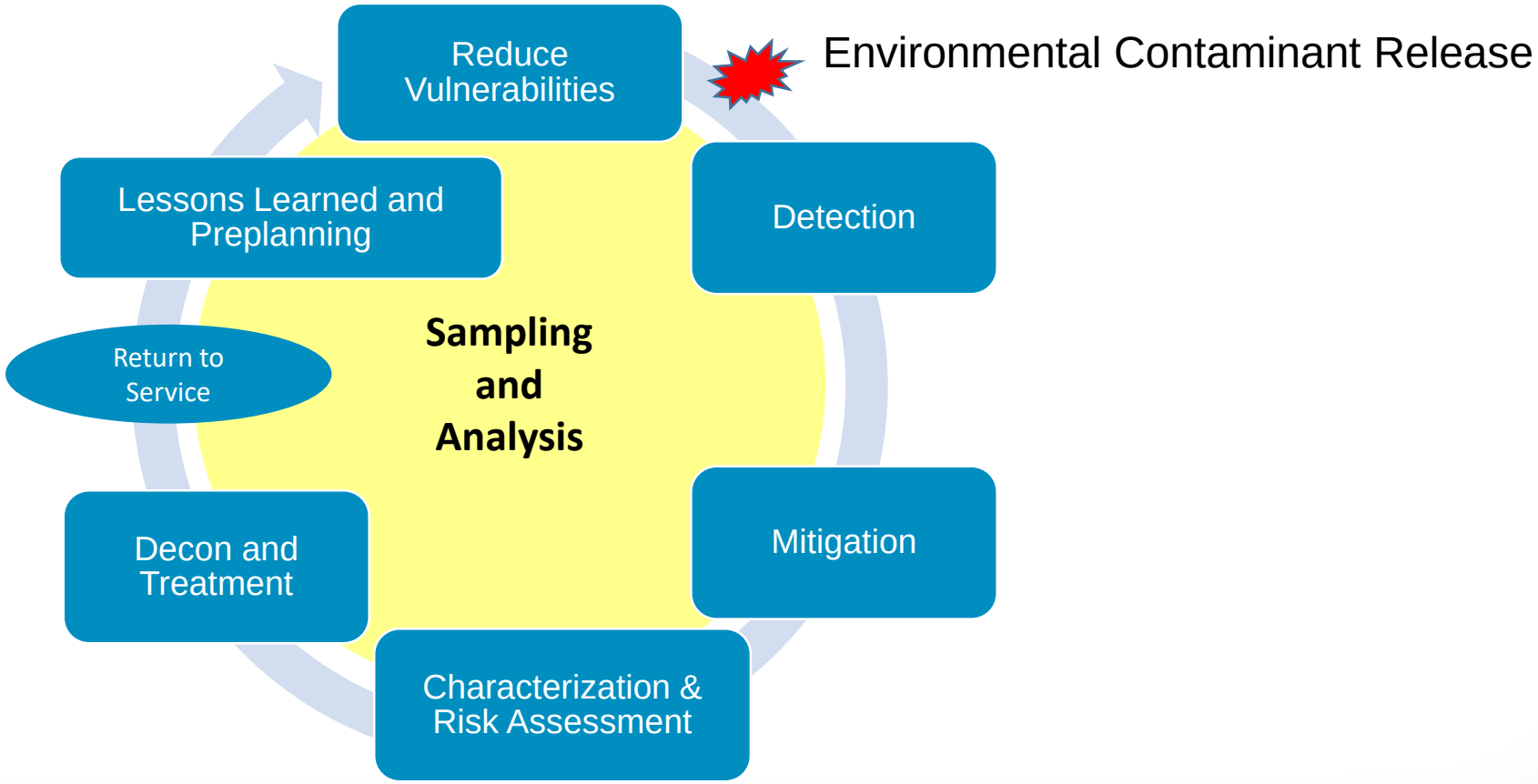
Multiple chemical contamination incidents have occurred in the United States and worldwide:

- **Deepwater Horizon oil spill (April 2010)**
- **Kalamazoo River oil spill (July 2010)**
- **CWA sulfur mustard clam shells (2010)**
- **Syrian civil war CWA chemical attacks (March-August 2013 and April 2014-current)**
- **Elk River chemical spill in West Virginia (January 2014)**
- **Flint, Michigan water crisis (April 2014)**
- **Arsenic-contaminated soil in Kentucky potentially containing CWA Lewisite (March 2015)**
- **Gold King Mine (August 2015)**
- **Corpus Christi, TX drinking water contamination (December 2016)**

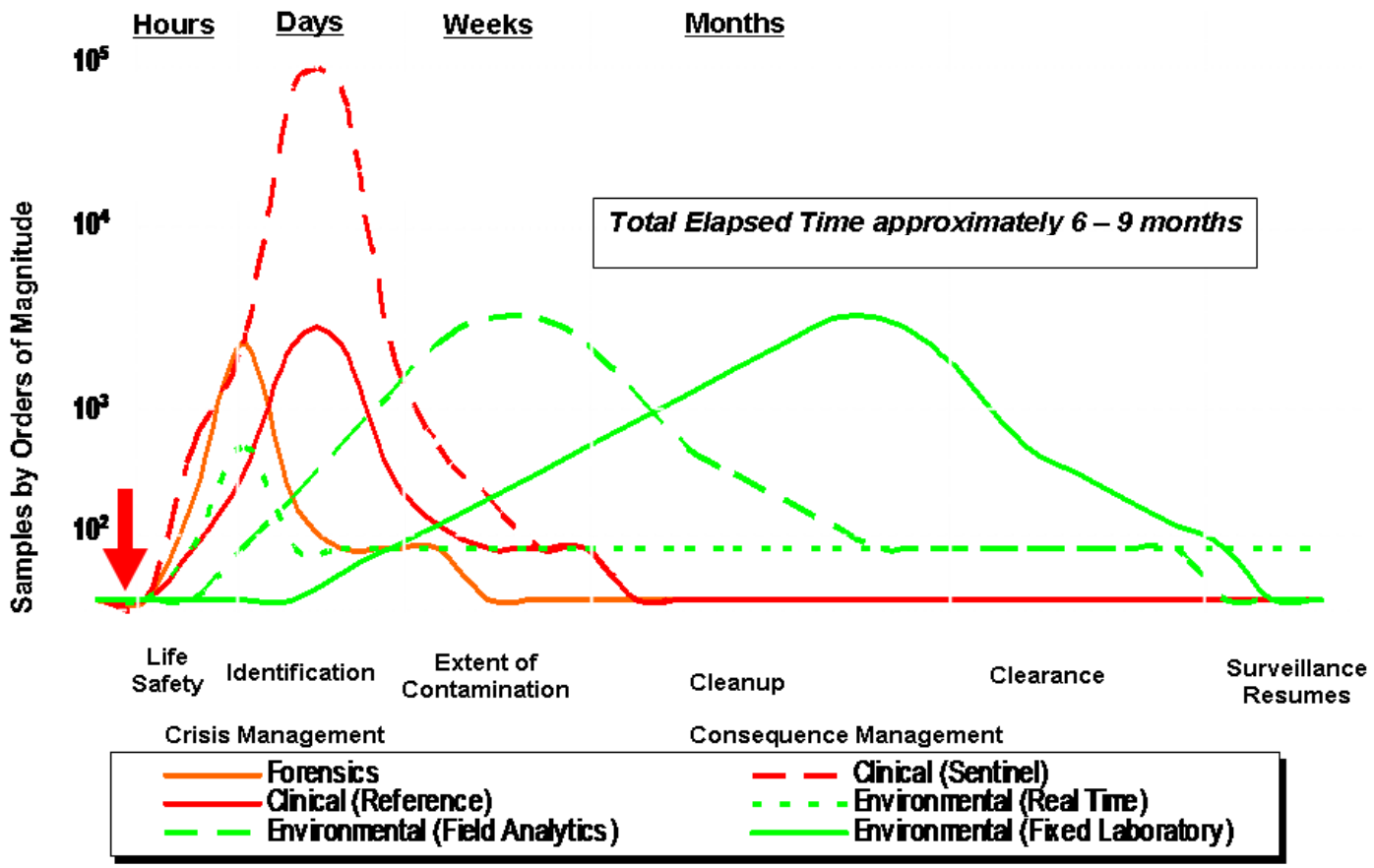
State and Local Levels

- **Recurring pesticide misuse cases (*e.g.*, bedbugs in apartment complexes and homes)**
- **Recurring drug misuse cases (*e.g.*, opioids - fentanyl)**

What do these responses have in common?

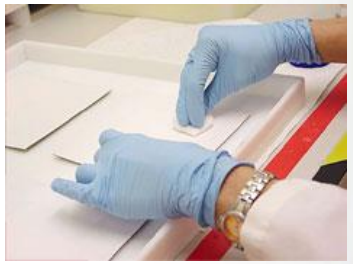


Sample Collection Effect on Lab Capacity and Capability During an Incident



Identifying Sampling and Analysis Gaps

- Selection of appropriate sampling and analysis method to accommodate lab capacity and capability
  - Selected Analytical Methods (SAM)
  - Addressing Analytical Gaps
- Effect of porous/permeable surfaces on analyte recoveries and alternative sampling strategies
  - Addressing Sampling Variables/Gaps



What are Selected Analytical Methods?

>1000 analyte/ sample type pairings

Chemicals	Radiochemicals	Pathogens	Biotoxins
• 145 chemicals • 5 sample types (solid, aqueous liquids, drinking water, air and wipes)	• 36 radiochemicals • 6 environmental sample types (drinking eater, aqueous and liquid phase, soil and sediment, surface wipes, air, and vegetation) • 4 building material sample types (asphalt shingles, asphalt matrices, concrete, and brick)	• 33 pathogens • 5 sample types (aerosol, particulate, soil, drinking water, and post-decontamination waste water)	• 18 biotoxins • 5 sample types (aerosol, solid, particulate, non-drinking water, and drinking water)

Searchable online: https://www.epa.gov/homeland-security-research/sam

Impact of Selected Analytical Methods

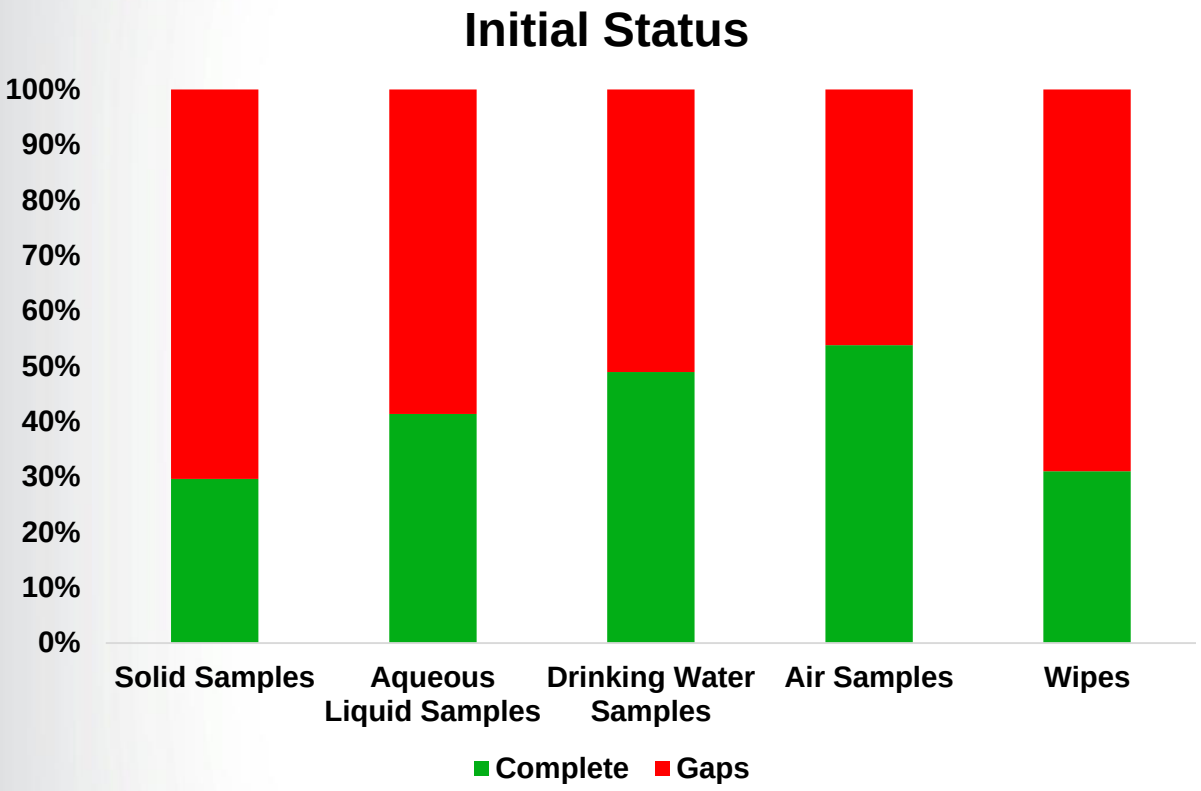
An available single, selected method for each analyte/sample type pairing. Using the same method would:

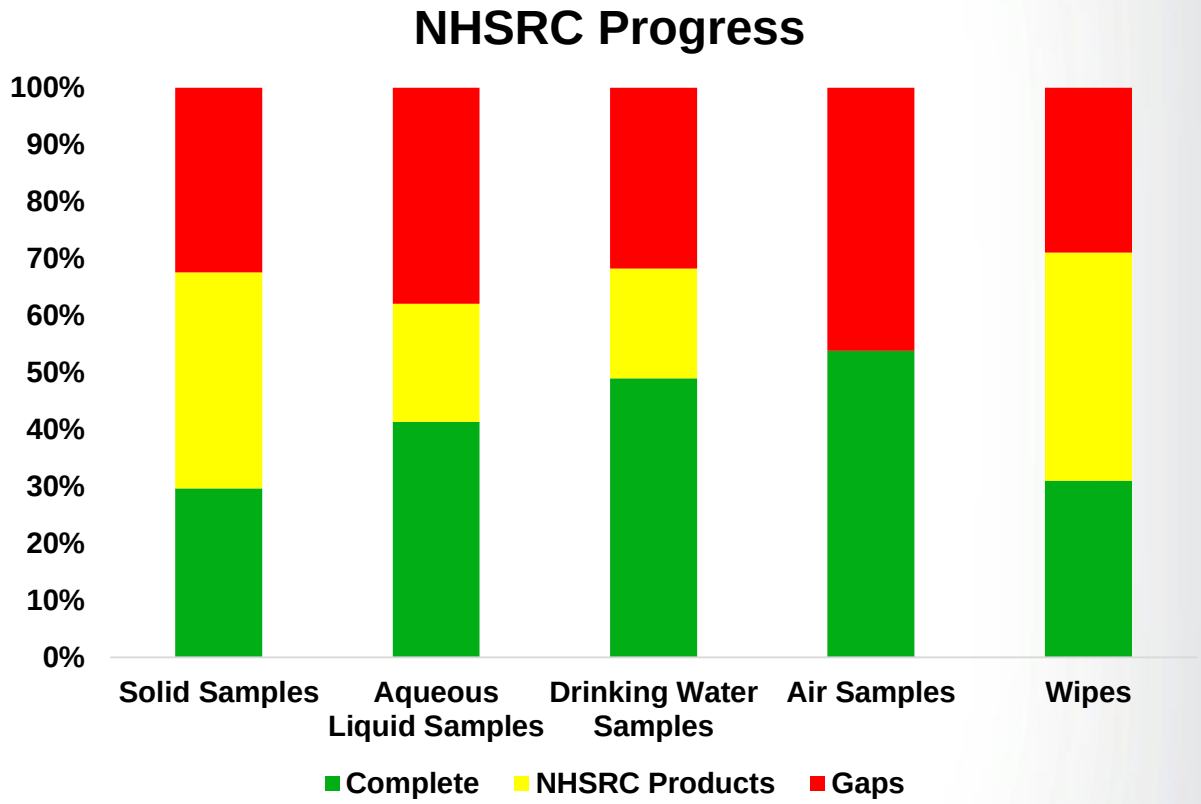
- Permit sharing of sample load between laboratories
- Potentially increase the speed of analysis
- Improve data comparability
- Simplify outsourcing analytical support

Assessing Quality and Confidence of SAM Methods

SAM Applicability Tier I	**Analyte/sample type is a target of the method**. Multi-laboratory evaluated will allow implementation for the analyte/sample type with no modifications. Data available for all aspects of method performance and quality control measures supporting its use.
SAM Applicability Tier II	**Method has been used by laboratories to address the analyte/sample type, but not multi-lab validated.** (1) The analyte/sample type is a target of the method, but method performance/quality control measures need further evaluation (e.g., single-lab tested). (2) The analyte/sample type is not a target of the method, but limited data for method performance/ quality control may be available.
SAM Applicability Tier III	**Analyte/sample type is not a target of the method, and/or no reliable data supporting the method's fitness for its intended use are available**.

Agency Gaps and Needs Related to SAM and EPA's ERLN

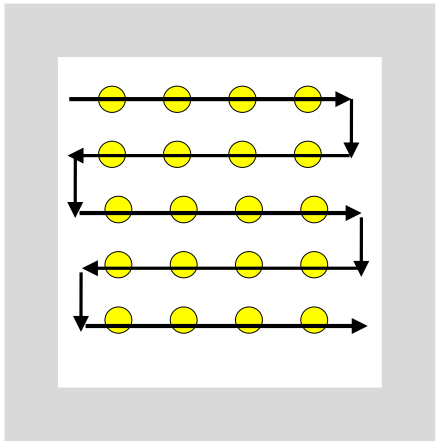


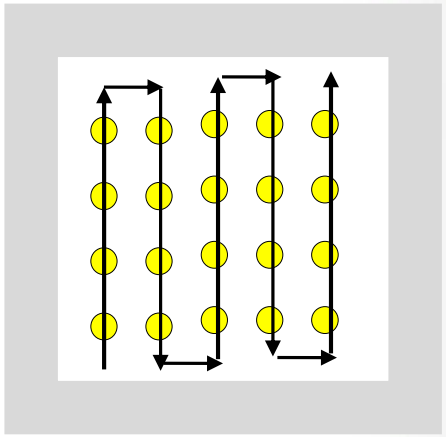


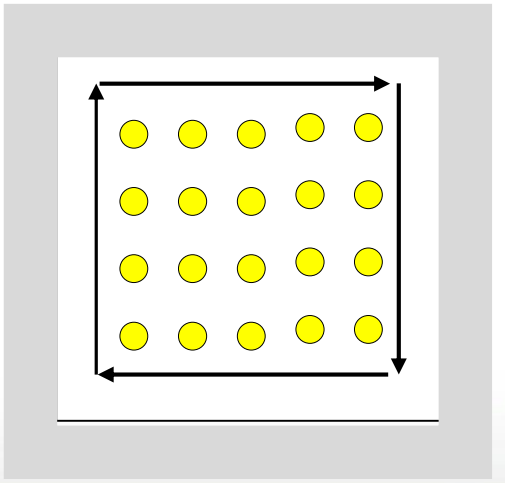
Analyte(s)	CAS RN	Notes	Solid Samples	Aqueous Liquid Samples	Drinking Water Samples	Air Samples	Wipes
Fluoroacetic acid and fluoroacetate salts (analyze as fluoroacetate ion)	N/A	**Red** = No developed method or not tested with listed method, no or limited data	Adapted from J. Chromatogr. A (2007) 1139: 271-278 Adapted from J. Chromatogr. A (2007) 1139: 271-278	Adapted from J. Chromatogr. A (2007) 1139: 271-278	Adapted from J. Chromatogr. A (2007) 1139: 271-278	Adapted from J. Chromatogr. A (2007) 1139: 271-278	Adapted from J. Chromatogr. A (2007) 1139: 271-278

Surface Wiping Procedure

- Analyte was added to the surface, allowed to dry completely (approximately 60-90 minutes depending on droplet size), and wiped.
- Each surface was wiped in the horizontally and vertically, as well as around the perimeter, and placed in the same sampling container for processing.
- Tested Wetting Solvents:
  - Acetonitrile, Methanol, Isopropyl Alcohol
- Tested Surfaces:
  - Metal, Glass, Laminate, Vinyl Tile, Painted Drywall
- Method detection limit, holding time, and precision and accuracy data were collected

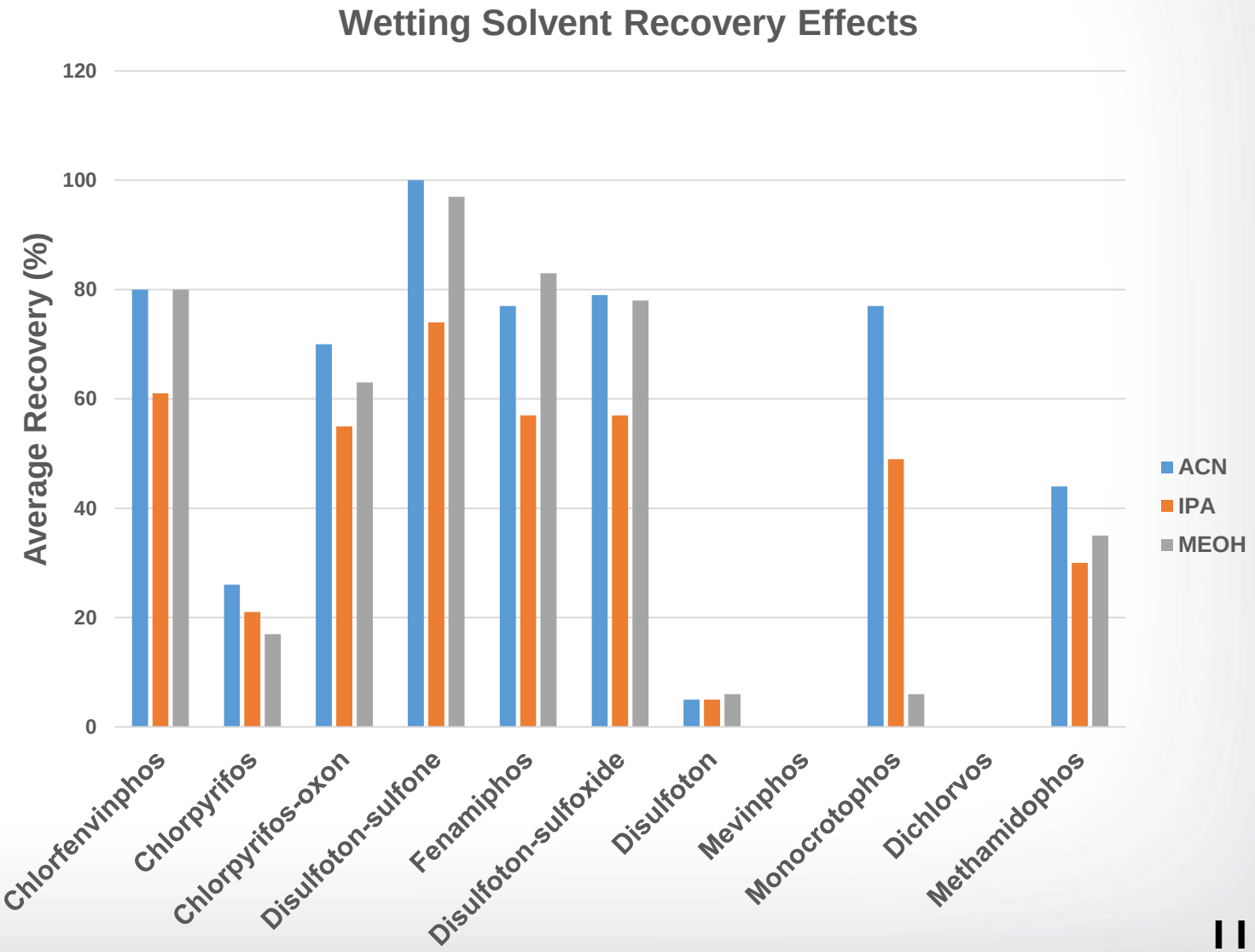






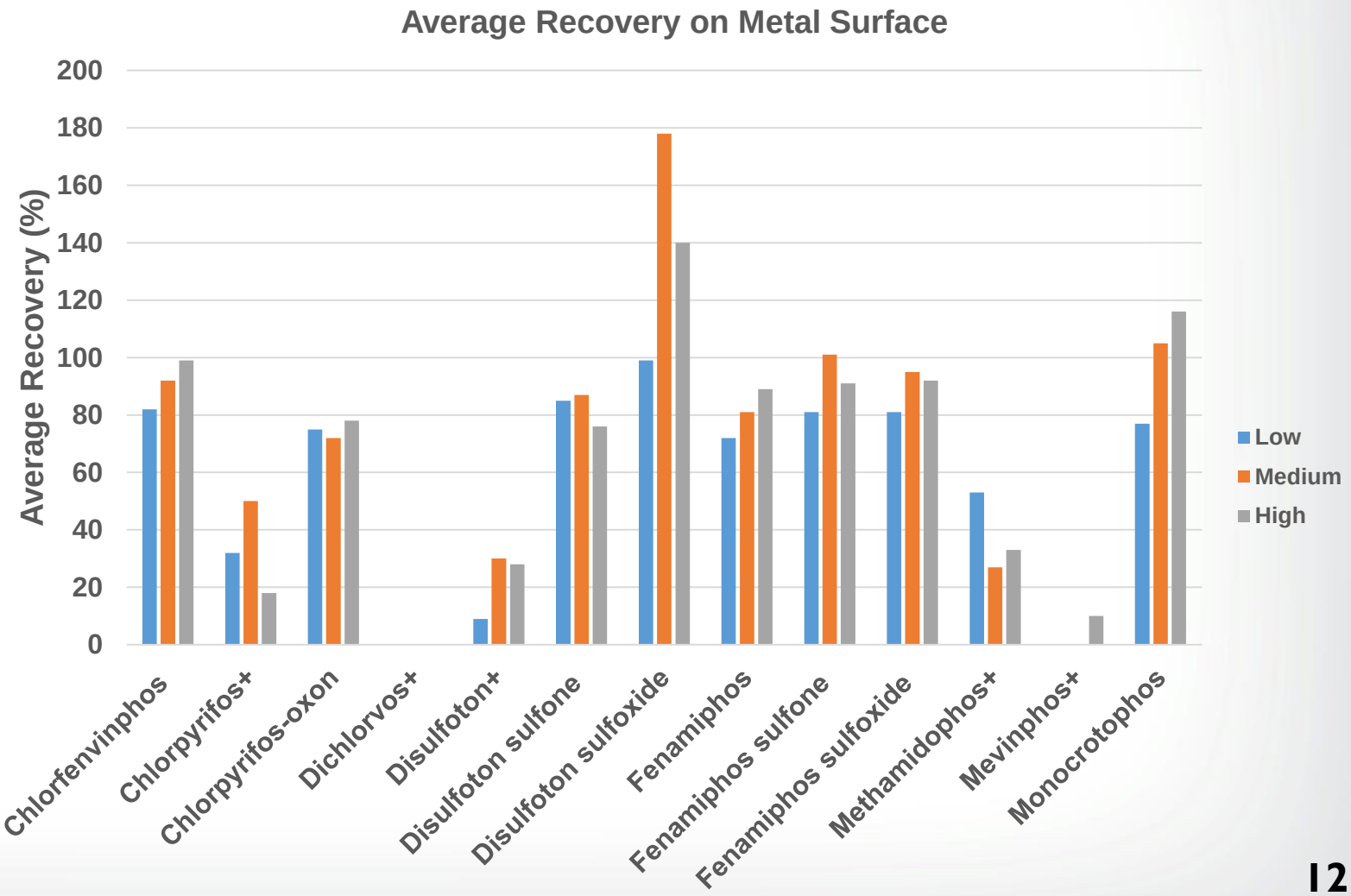
Wetting Solvent Effects on Recoveries

- Cotton gauze wipes were tested with three wetting solvents
- Wipes were spiked directly with target analytes after wetting with 1mL of solvent
- Eight tested analytes provided acceptable recoveries (> 70%) with low RSD values
- Five tested analyte recoveries were low (< 50%), had high variability (> 30%) or combination of both
- Acetonitrile was chosen because it had the highest recoveries and lowest variability amongst all the tested analytes



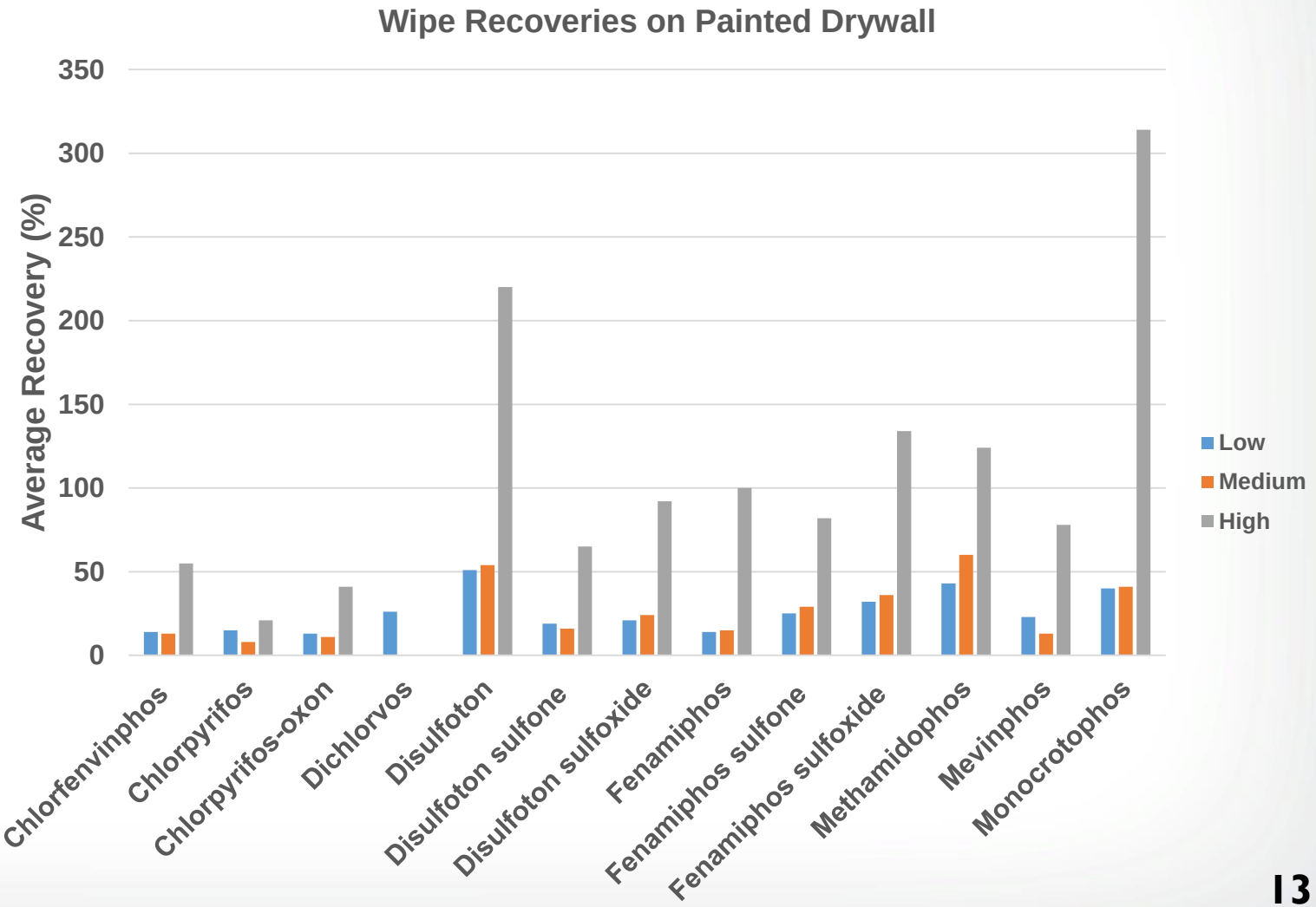
Precision & Accuracy Wipe Recovery Data on Metal

- **Concentrations correspond to the low and middle of the calibration curve (3, 4, and 5 levels)**
- **Acceptable recoveries were obtained for 8 of the 13 tested analytes on non-porous surface (analytes with (+) resulted in poor recoveries)**
- **Potential complications were most likely due to poor ionization, volatility or matrix interferences**



Precision & Accuracy Wipe Recovery Data on Painted Drywall

- **Concentrations correspond to the low and middle of the calibration curve (3, 4, and 5 levels)**
- **Recoveries were low (< 70%) and variability was higher than from metal surface for all tested analytes**
- **Porous/permeable surface likely resulted in analyte recovery losses and matrix interferences**



Method Detection Limit Data on Metal Surface

- **MDL values were calculated for all tested analytes based on EPA *Code of Federal Regulations*, 40 CFR Part 136, Appendix B. Definition and Procedure for the Determination of the Method Detection Limit – Revision 1.11.**
- **The procedure works best for 8 of the tested 13 analytes based on the data obtained from all surfaces.**
- **Further investigation is needed for chlorpyrifos, dichlorvos, disulfoton, mevinphos, and methamidophos.**

METAL SURFACE			
Analyte	MDL		MRL
	ng/cm² †	ng/mL	ng/mL
Chlorfenvinphos	0.013	1.3	4
Chlorpyrifos	0.10	10	33
Chlorpyrifos-oxon	0.022	2.2	7
Dichlorvos*	0.075	7.5	75
Disulfoton*	0.050	5.0	50
Disulfoton sulfone	0.025	2.5	26
Disulfoton sulfoxide	0.013	1.3	8
Fenamiphos	0.010	1.0	3
Fenamiphos sulfone	0.047	4.7	15
Fenamiphos sulfoxide	0.038	3.8	12
Methamidophos	0.016	1.6	5
Mevinphos*	0.025	2.5	25
Monocrotophos	0.010	1.0	2

*The lowest calibration level is presented as the MDL value. ESI^+ ionization mode provided the method detection limit (MDL) and minimum reporting level (MRL) values. MRL levels are conservative and the lowest calibration level may suffice, where applicable, as the MRL value.
†ng/cm² calculation was performed by dividing the concentration spiked onto the surface by the test area of the coupon (100 cm²).

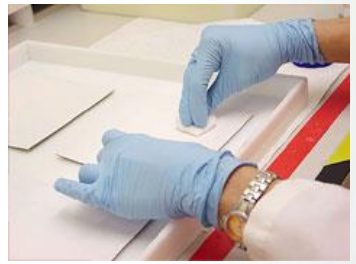
Organophosphorus Pesticide Wipe Recovery Summary

- **Data obtained from all surfaces suggest that the sampling and analysis procedure works best for 8 of 13 tested analytes.**
  - Suitable method for chlorfenvinphos, chlorpyrifos-oxon, disulfoton-sulfone, disulfoton sulfoxide, fenamiphos, fenamiphos-sulfone, fenamiphos-sulfoxide, and monocrotophos
  - Further method development is needed for chlorpyrifos, dichlorvos, disulfoton, methamidophos, and mevinphos
- **Possible explanations for poor recoveries from the remaining five analytes include volatility, matrix enhancement/suppression effects associated with ESI-LC-MS/MS, surface matrix effects or degradation of the compound.**
- **Non-porous/non-permeable surface recoveries obtained from wipe extracts were higher (> 70%) than from porous/permeable surface.**
- **Data suggest that wetting solvents affect analyte recovery.**

Identifying Sampling and Analysis Gaps

- Selection of appropriate sampling and analysis method to accommodate lab capacity and capability
    - Selected Analytical Methods (SAM)
    - Addressing Analytical Gaps

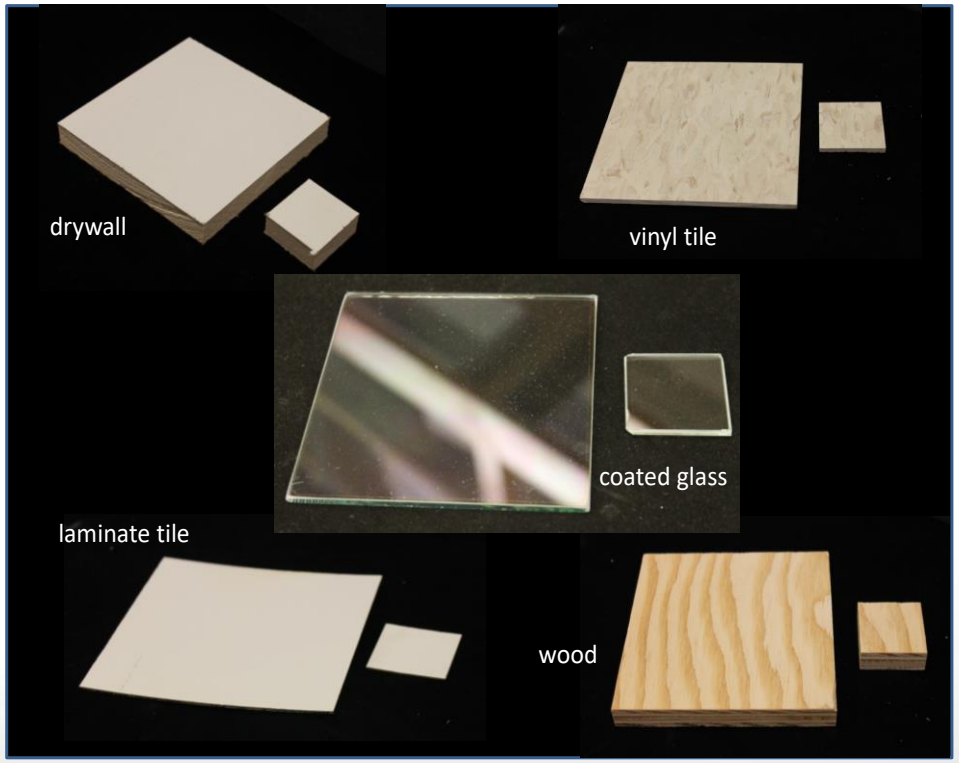
- Effect of porous/permeable surfaces on analyte recoveries and alternative sampling strategies
    - Addressing Sampling Variables/Gaps



Sampling Strategies and Method Development

- **Collaborative efforts with CDC's National Institute for Occupational Safety and Health, EPA's Office of Pesticide Program, National Risk Management Research Laboratory and National Exposure Risk Laboratory have focused on sampling strategies and method development to better understand how sampling variables affect data analysis and ways data confidence can be improved for decision-makers during emergency response scenarios.**

- **Tested Variables:**
  - **Phase 1:**
    - **Wetting solvent**
    - **Wipe type**
  - **Phase 2**
    - **Concentration**
    - **# of wipes per surface**
  - **Phase 3**
    - **Formulations vs. neat analyte**
    - **Surface type**



Tested Commercial Product Concentrations

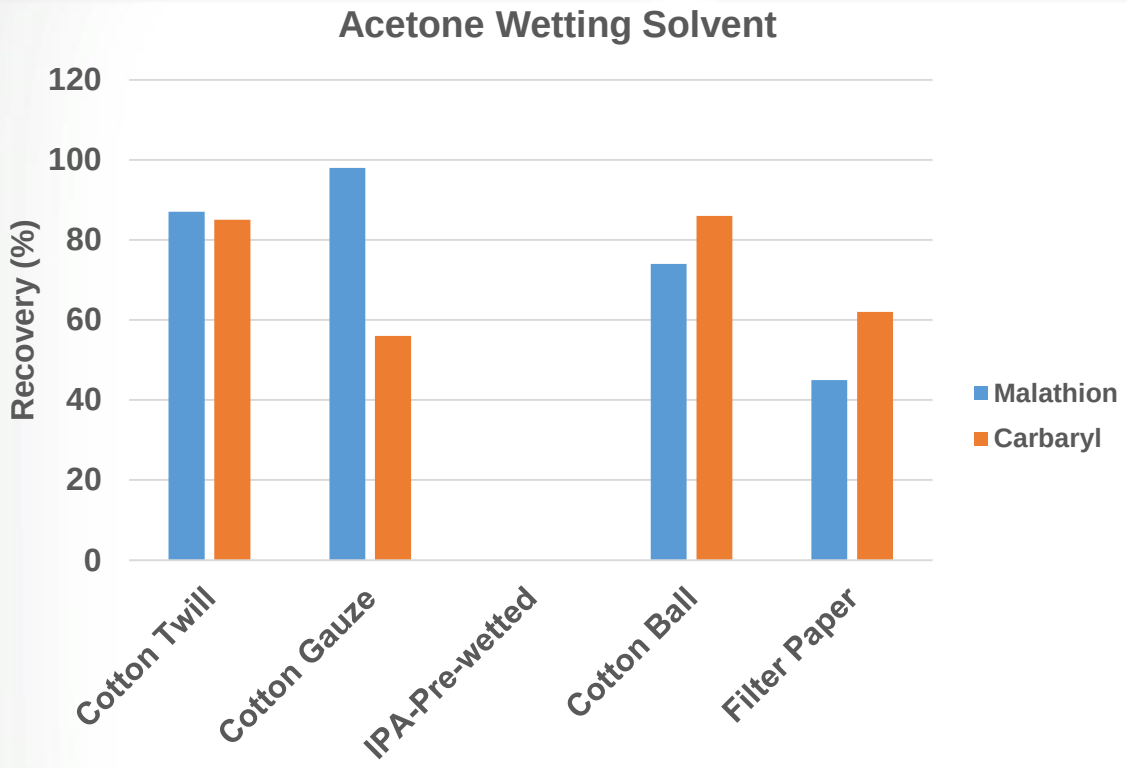
- **High concentrations reported from incidents where pesticide misuse occurred**
- **Availability of commercial products can be easily purchased and over-applied**
  - **"Works Great! Kills Everything! I mix mine 9 tbsp per gallon for mosquito control and it kills everything it touches! I tried lower mix on garden shrubs 2 tbsp per gallon and it worked well on the plants also. Finally a product that works! Everyone else that had problems with it working probably mixed it 2 tbsp per gallon but the last entry shows it takes 8 for spiders and roaches and 9 for mosquito control. Don't be worried it works great." – 7/15/2016**
  - **Bottle makes 48 gallons, per instructions, ~ 1.3 tbsp/gallon**
- **IDLH- Immediately Dangerous to Life or Health**

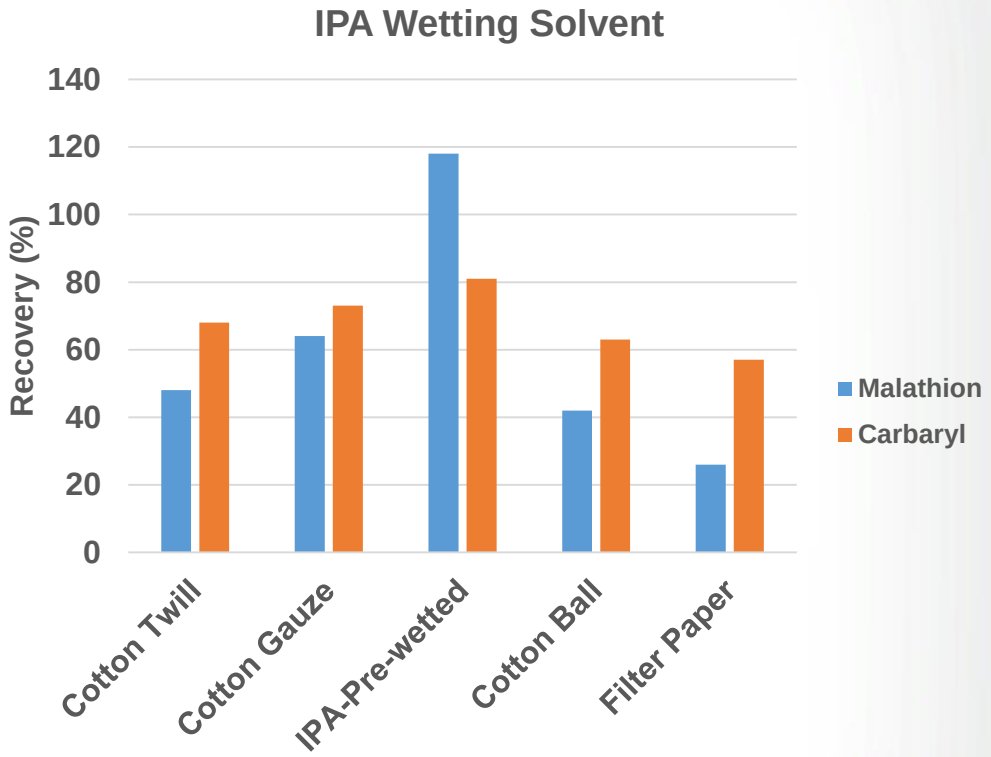
Sample Location	Surface Area	Carbaryl Concentration
Kitchen (e.g., metal, vinyl tile)	12 in x 12 in	24 mg
Bedroom (painted drywall, wood)	12 in x 12 in	24 mg
IDLH*	100 mg/m^3	

Sample Location	Surface Area	Malathion Concentration
Bedroom (painted drywall, wood)	12 in x 12 in	4 mg
IDLH*	250 mg/m^3	

**CDC – NIOSH Pocket Guide to Chemical Hazards, https://www.cdc.gov/niosh/npg.*

Wetting Solvent Effects on Wipe Recoveries





Phase 1

- **Five wipe types were tested with two wetting solvents**
  - **Acetone**
  - **Isopropyl Alcohol**
- **Malathion (OP) and Carbaryl (carbamate) were tested on impermeable (steel) surface with only one wipe/surface**

Composite Malathion Recoveries at High Concentrations (4 mg/coupon)

Phase 2

- High concentrations of malathion were evaluated on steel surface with four wipe materials
- IPA wetting solvent used for all wipe materials
- Three wipes were used to wipe the surface. Each wipe was used and analyzed separately
- At high concentrations, most of the target analyte is recovered with the first two wipes

	Cotton Twill (TW)			Cotton Gauze (CG)		
Wipe #	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.
1A	4000	2131	53	4000	629	16
2A	4000	703	18	4000	386	10
3A	4000	171	4	4000	286	7
Composite	4000	3005	75	4000	1301	33
1B	4000	1898	47	4000	708	18
2B	4000	748	19	4000	280	7
3B	4000	329	8	4000	279	7
Composite	4000	2974	74	4000	1267	32
1C	4000	1892	47	4000	399	10
2C	4000	740	19	4000	387	10
3C	4000	337	8	4000	264	7
Composite	4000	2969	74	4000	1050	26
Composite RSD			1	Composite RSD		11

Composite Malathion Recoveries at High Concentrations (4 mg/coupon)

Phase 2, cont.

- High concentrations of malathion were evaluated on steel surface with four wipe materials
- IPA wetting solvent used for all wipe materials
- Three wipes were used to wipe the surface. Each wipe was used and analyzed separately
- At high concentrations, most of the target analyte is recovered with the first two wipes
- IPA-PW wipe recoveries from the first wipe are higher than other reported wipes

	Cotton Ball (CB)			IPA Pre-wetted (IPA-PW)		
Wipe #	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.
1A	4000	1549	39	4000	2829	71
2A	4000	1137	28	4000	669	17
3A	4000	352	9	4000	228	5
Composite	4000	3038	76	4000	3726	93
1B	4000	1193	30	4000	2461	62
2B	4000	1111	28	4000	776	19
3B	4000	639	16	4000	200	5
Composite	4000	2943	74	4000	3438	86
1C	4000	2237	56	4000	2368	59
2C	4000	783	20	4000	698	18
3C	4000	258	6	4000	255	6
Composite	4000	3278	82	4000	3321	83
Composite RSD			6	Composite RSD		6

Composite Malathion Recoveries at Low Concentrations (0.3 mg/coupon)

Phase 2, cont.

- Low concentrations of malathion were evaluated on steel surface with four wipe materials
- IPA wetting solvent used for all wipe materials
- Three wipes were used to wipe the surface. Each wipe was used and analyzed separately
- At low concentrations, most of the target analyte is recovered with the first two wipes

	Cotton Twill (TW)			Cotton Gauze (CG)		
Wipe #	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.
1A	6000	3001	50	6000	1020	17
2A	6000	1031	17	6000	475	8
3A	6000	413	7	6000	470	8
Composite	6000	4445	**74**	6000	1965	**33**
1B	6000	3219	54	6000	769	13
2B	6000	794	13	6000	411	7
3B	6000	447	7	6000	307	5
Composite	6000	4460	**74**	6000	1487	**25**
1C	6000	3057	51	6000	746	13
2C	6000	770.7	13	6000	322	5
3C	6000	419.7	7	6000	289	5
Composite	6000	4247	**71**	6000	1357	**23**
Composite RSD			3	Composite RSD		20

Composite Malathion Recoveries at Low Concentrations (0.3 mg/coupon)

Phase 2, cont.

- Low concentrations of malathion were evaluated on steel surface with four wipe materials
- IPA wetting solvent used for all wipe materials
- Two wipes were used to wipe the surface. Each wipe was used and analyzed separately
- At low concentrations, most of the target analyte is recovered with the first two wipes
- IPA-PW wipe recoveries from the first wipe are higher than other reported wipes

	Cotton Ball (CB)			IPA Pre-wetted (IPA-PW)		
Wipe #	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.
1A	6000	2481	42	6000	3697	61
2A	6000	1633	27	6000	163	3
Composite	6000	4114	**69**	6000	3860	**64**
1B	6000	3389	56	6000	3725	62
2B	6000	1174	20	6000	359	6
Composite	6000	4563	**76**	6000	4084	**68**
1C	6000	5014	84	6000	3488	58
2C	6000	914	15	6000	1223	20
Composite	6000	5928	**99**	6000	4711	**78**
Composite RSD			19	Composite RSD		11

Malathion Results Summary

- **Wetting solvent may play a role in analyte recovery (e.g., solubility)**
  - **Depending on the setting, field sampling teams may have limited solvent options (surface destruction, health hazard, etc.)**
- **Data suggest that concentration does not affect malathion recoveries at the tested levels (4 mg vs. 0.3 mg)**
- **Data suggest that two wipes are sufficient to allow adequate malathion recoveries from a non-permeable surface**
  - **IPA-PW wipe appeared to recover more with the first wipe than other tested wipes**
- **Wipe type and composition may play a role in analyte recovery especially when considering commercial products**

Composite Carbaryl Recoveries at High Concentrations (24 mg/coupon)

Phase 2

- High concentrations of carbaryl were evaluated on steel surface with four wipe materials
- IPA wetting solvent used for all wipe materials
- Three wipes were used to wipe the surface. Each wipe was used and analyzed separately
- At high concentrations, most of the target analyte is recovered with the first wipe for TW and CG wipes

	Cotton Twill (TW)			Cotton Gauze (CG)		
Wipe #	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.
1A	4800	4169	87	4800	5002	104
2A	4800	608	13	4800	214	4
3A	4800	261	5	4800	119	3
Composite	4800	5038	105	4800	5335	111
1B	4800	4650	97	4800	5106	106
2B	4800	895	19	4800	266	6
3B	4800	401	8	4800	131	3
Composite	4800	5946	124	4800	5503	115
1C	4800	4324	90	4800	4691	98
2C	4800	898	19	4800	230	5
3C	4800	276	6	4800	111	2
Composite	4800	5498	115	4800	5032	105
Composite RSD			8	Composite RSD		5

Composite Carbaryl Recoveries at High Concentrations (24 mg/coupon)

Phase 2, cont.

- High concentrations of carbaryl were evaluated on steel surface with four wipe materials
- IPA wetting solvent used for all wipe materials
- Three wipes were used to wipe the surface. Each wipe was used and analyzed separately
- At high concentrations, most of the target analyte is recovered with the first wipe for IPA-PW and two wipes for CB (wipe size may play a role).

	Cotton Ball (CB)			IPA Pre-wetted (IPA-PW)		
Wipe #	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.
1A	4800	2373	49	4800	3641	76
2A	4800	794	17	4800	781	16
3A	4800	531	11	4800	407	9
Composite	4800	3698	77	4800	4829	101
1B	4800	3203	67	4800	3142	66
2B	4800	734	15	4800	1244	26
3B	4800	242	5	4800	402	8
Composite	4800	4180	87	4800	4788	100
1C	4800	2569	54	4800	3649	76
2C	4800	954	20	4800	978	20
3C	4800	502	10	4800	386	8
Composite	4800	4025	84	4800	5013	104
Composite RSD			6	Composite RSD		3

Composite Carbaryl Recoveries at Low Concentrations (0.5 mg/coupon)

Phase 2, cont.

- Low concentrations of carbaryl were evaluated on steel surface with four wipe materials
- IPA wetting solvent used for all wipe materials
- Three wipes were used to wipe the surface. Each wipe was used and analyzed separately
- At low concentrations, most of the target analyte is recovered with the first two wipes

	Cotton Twill (TW)			Cotton Gauze (CG)		
Wipe #	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.
1A	5000	4078	82	5000	2990	60
2A	5000	1538	31	5000	1874	38
3A	5000	685	14	5000	736	15
Composite	5000	6302	126	5000	5601	112
1B	5000	3947	79	5000	2917	58
2B	5000	1331	27	5000	759	15
3B	5000	752	15	5000	485	10
Composite	5000	6031	121	5000	4161	83
1C	5000	4366	87	5000	2030	41
2C	5000	1051	21	5000	930	19
3C	5000	336	7	5000	324	6
Composite	5000	5753	115	5000	3284	66
Composite RSD			5	Composite RSD		27

Composite Carbaryl Recoveries at Low Concentrations (0.5 mg/coupon)

Phase 2, cont.

- Low concentrations of carbaryl were evaluated on steel surface with four wipe materials
- IPA wetting solvent used for all wipe materials
- Two wipes were used to wipe the surface. Each wipe was used and analyzed separately
- At high concentrations, most of the target analyte is recovered with the first wipe for IPA-PW and two wipes for CB (wipe size may play a role).

	Cotton Ball (CB)			IPA Pre-wetted (IPA-PW)		
Wipe #	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	% Rec.
1A	5000	2402	48	5000	2969	59
2A	5000	934	19	5000	1195	24
Composite	5000	3336	67	5000	4164	83
1B	5000	1656	33	5000	2992	60
2B	5000	1527	31	5000	1233	25
Composite	5000	3183	64	5000	4225	85
1C	5000	1951	39	5000	3478	69
2C	5000	1312	26	5000	1032	21
Composite	5000	3263	65	5000	4510	90
Composite RSD			2	Composite RSD		4

Carbaryl Results Summary

- **Wetting solvent may play a role in analyte recovery (e.g., solubility)**
  - **Depending on the setting, field sampling teams may have limited solvent options (surface destruction, health hazard, etc.)**
- **Data suggest that concentration does not affect carbaryl recoveries at the tested levels (24 mg vs. 0.5 mg)**
- **Data suggest that two wipes are sufficient to allow adequate carbaryl recoveries from a non-permeable surface (> 70 %)**
- **Wipe type and composition may play a role in analyte recovery especially when considering commercial products**

Tested Alternative Surface Types

Phase 3

- Malathion and carbaryl were tested on vinyl tile, plywood, painted drywall and glass
- Two wipes (TW, IPA-PW and CG) were used on the tested surfaces and analyzed together
- IPA wetting solvent
- Porous-permeable surfaces resulted in low, poor recoveries
- Non-permeable/non-porous surfaces resulted in higher, acceptable recoveries (>70 %)

Malathion (4 mg/coupon)				Carbaryl (24 mg coupon)		
Twill Wipe (TW)				Twill Wipe (TW)		
Surface Type	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	Average % Rec.	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	Average % Rec.
Vinyl	4000	286	7	4800	384	8
Plywood	4000	40	1	4800	32	1
IPA Pre-wetted (IPA-PW)				IPA Pre-wetted (IPA-PW)		
Painted Drywall	4000	52	1	4800	50	1
Glass	4000	2905	73	4800	3926	82
Cotton Gauze (CG)				Cotton Gauze (CG)		
Painted Drywall	4000	150	4	4800	69	1
Glass	4000	3134	78	4800	4615	96

Technical Formulations on Surfaces

Phase 3, cont.

- Technical solutions of malathion and carbaryl (commercial products) were tested on vinyl tile, plywood, painted drywall, glass and metal
- Two wipes (TW, IPA-PW and CG) were used on the tested surfaces and analyzed together
- IPA wetting solvent
- Porous-permeable surfaces resulted in low, poor recoveries, except vinyl tile with TW wipe
- Non-permeable/non-porous surfaces resulted in higher, acceptable recoveries (>70 %), except TW wipe on metal (61 %)

Technical Formulation Malathion (Ortho Max)				Technical Formulation Carbaryl (Sevin)		
Surface Type	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	Average % Rec.	Spiked Conc. (ng/ml)	Calculated Conc. (ng/ml)	Average % Rec.
Twill Wipe (TW)				Twill Wipe (TW)		
Vinyl	4000	92	2	4800	3957	82
Plywood	4000	30	1	4800	35	1
Metal	4000	2449	61	4800	5010	104
IPA Pre-wetted (IPA-PW)				IPA Pre-wetted (IPA-PW)		
Painted Drywall	4000	60	2	4800	312	7
Glass	4000	4933	124	4800	3719	77
Metal	4000	3117	78	N/A	N/A	N/A
Cotton Gauze (CG)				Cotton Gauze (CG)		
Painted Drywall	4000	112	3	4800	865	18
Glass	4000	3940	99	4800	5257	110
Metal	4000	3290	82	4800	5261	132

Alternative Surface and Commercial Product Results

- As expected, neat malathion and carbaryl recoveries on non-porous/non-permeable solutions resulted in acceptable recoveries (> 70%) and porous/permeable solutions resulted in low recoveries.

- Technical solutions of the target analytes behaved similarly to that of the neat solutions on the tested surfaces, except carbaryl on vinyl tile with the TW wipe.

- Malathion technical formulation recoveries may have allowed for the analyte to “sit” on the surface, thus, allowing for slightly greater recoveries than from neat solutions, although further testing is needed.

Summary and Conclusions

- **Many wipe variables were tested in order to provide a better understanding of the data collected from surfaces during wipe sampling and analysis.**
- **Wipe recovery data can be highly variable even on non-porous/non-permeable surfaces. Caution should be exercised when analyzing data associated with surface wiping to determine the source of low recoveries when they occur.**
- **Matrix interferences associated with surfaces should be expected; however, wetting solvent, wipe type, and the number of wipes used to wipe a surface are anticipated to increase surface recovery results to an extent.**
- **The number of variables associated with wipe sampling can be reduced if steps are taken to control specific parameters, thus, resulting in consistent and more robust data.**
  - **Wipe type**
  - **Number of wipes used per surface**
  - **Wipe sampling protocols**

Contributors

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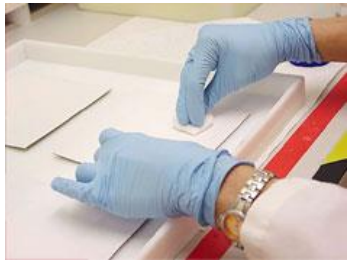

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