

# **Comments on Sampling and Analyzing Wildfire Smoke Residues**

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## **Eugenia Mirica, Ph.D.**

- **Director, Materials Analysis; EMSL Laboratories**
  - **Expert, laboratory methods of analysis**
    - **Wildfire smoke residues**
- **Develop Standard Operating Procedures (SOP) that will reliably analyze the client's samples**
  - **Tape lift, wipe sample, micro-vacuum cassette**
  - **Research, testing, validation, and quality control**
  - **Criteria for evaluating & monitoring this process**
- **Each laboratory develops their own SOP's**
  - **Can vary between laboratories, even facilities**

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## **Joe Spurgeon, Ph.D., CIH (1993–2012)**

- **University of Pittsburgh [Air Pollution Fellow]**
  - **Qualified for**
    - **Ph.D. in Analytical Chemistry**
      - **Graduate School of Chemistry**
    - **DrPH in Environmental Health**
      - **Graduate School of Public Health**

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## **Fire Background**

- **Directed FAA's Combustion Toxicology Laboratory**
  - **Participated in numerous full scale fire tests**
  - **Worked closely with CAMI, various Fire Research Centers**
    - **NASA, NBS (NIST), Univ of Utah, Univ of San Francisco**
  - **Developed**
    - **Sampling and laboratory methods to measure concentration-time profiles of combustion products in full scale fires (Pub)**
    - **First anion detector & method for Ion Chromatography (Pub)**
    - **New animal test methods for fire environments (Published)**
    - **New methods for assessing toxicity (Published)**
    - **Animal data-telemetry methods (published)**
- **Courses taught: Introduction to Fire Science & Fire Hydrology**

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## PRV Sampling: Transportation Accidents

US Air Flight 1549



Continental Flight 3407



Amtrak, Fallon, NV



Raytheon, El Segundo, CA



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## Items and Materials Tested in Transportation Fires

- Luggage
- Clothing
- Shoes & Belts
- Coats & Furs
- Electronics
- Jewelry
- Toys
- Hard plastics
- Soft plastics
- Synthetic fabrics
- Natural fabrics
- Wood
- Paper & Cardboard
- Glass & Metal

Items similar to those in a house or office fire

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## Qualifications

- **What I have is practical experience and extensive knowledge in sampling methods**
- **What Eugenia has is extensive knowledge of laboratory methods for the analysis of fire and wildfire smoke residues**
  - **Tape Lifts, Wipe Samples, Micro-vacuum Samples**
- **Presenting Limited Data from Two Studies**
  - **Comparison of tape lift and wet-wipe samples**
  - **Characterization of wildfire smoke residues**

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## First Study

### **Direct Comparison of Tape Lifts and Wet Wipes (Seif, Spurgeon, Mirica)**

- **48 houses were sampled in so. CA**
- **Replicate (side-by-side) tape lift and wet-wipe samples were collected in each house**
- **Individual samples were collected from 3-5 spots and were composited by the laboratory for analysis**
- **96 Interior windowsill samples**
  - **48 tape lift and 48 wet-wipe composite samples**
- **96 Interior hard surface samples**
  - **48 tape lift and 48 wet-wipe composite samples**

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## Sample Analysis

- Analysis by EMSL Laboratories
  - Composited, sonicated, filtered, then analyzed
  - Samples examined by stereo-microscopy, reflected light microscopy, TEM/EDX, and SEM/EDX
  - Soot and ash were not detected in any sample
  - Laboratory confirmed this result was not unusual or specific to the wet-wipe method [Eugenia]
  - Char analysis by polarized light microscopy (PLM) and concentration (%-char) reported using the Visual Area Estimation method
- Therefore, methods were compared based on %-char

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## Visual Area Estimation Method

Developed by US EPA [EPA/600/R-93/116]

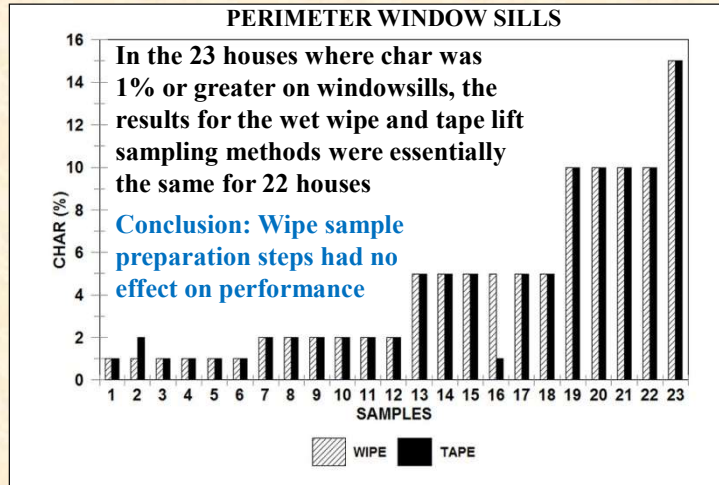
- The method assumes representative subsamples will be prepared from a homogenized sample, analyzed, and the results averaged
  - Difficult to increase homogeneity and decrease obscuration by debris particles in tape lift samples
  - The sample preparation steps for wipe samples and micro-vac cassettes increase subsample homogeneity and decrease obscuration by debris particles
- Composites allowed: Results are averaged either before or after sample collection in any case

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## EFFECTS OF SAMPLE PREPARATION

Tape lifts and wet-wipes performed the same on flat, relatively homogeneous surfaces

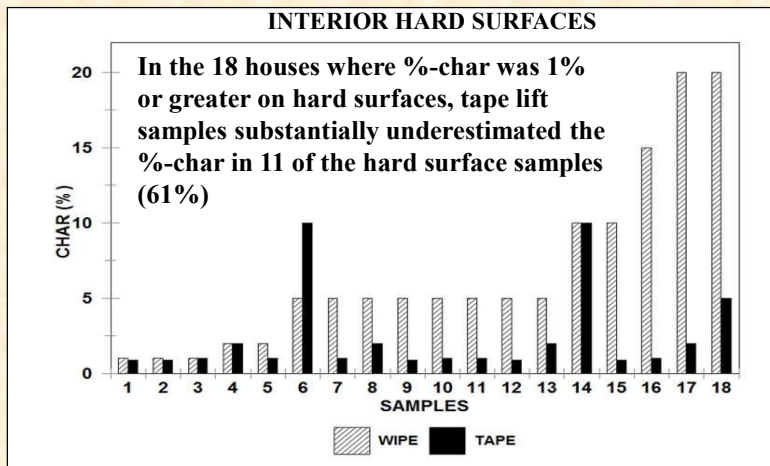


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## Assessing Impact

Wipes may have been better for collecting more representative samples on less homogeneous surfaces



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## Char on Interior Surfaces

	Windows	Windows	Interiors	Interiors
CHAR	Wipe	Tape	Wipe	Tape
<1%	25	25	30	34
1%	6	6	3	11
2%	6	7	2	4
5%	6	5	8	1
10%	4	4	2	2
>10%	1	1	3	0

### Results for %-char => 1%: Wet-Wipes Detected Char

Wet Wipes => 13 of 18 (72%) had %-char of 5% or greater

Tape Lifts => 15 of 18 (83%) had %-char of 1%-2%

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## Comparison of Methods

- Percentage of the 18 impacted houses in the previous table, based on interior hard surface results, that would be subject to restoration using the following criteria and sampling method.

METHOD	CRITERION	RESTORATION
Tape Lift	3% or more	17%
Wet Wipe	3% or more	72%
Wet Wipe	1% or more	100%

- “Criterion” is the assumed percent Char for a positive result.

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## Second Study

### Characterizing Wildfire Smoke Residues (Seif, Spurgeon)

2,058 wet wipe samples were collected from 343 houses

- Each sample a composite of 3-5 individual samples
- Analyzed for Char, Ash and Soot

- Six sampling locations in each house
  - Exterior surfaces
  - Interior hard surfaces
  - Attic surfaces
  - Air return plenums
  - Interior windowsills
  - Clothing

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## Char: Primary Wildfire Smoke Residue

Percentage of samples with => 1% residues  
in 2,058 samples collected from 343 houses

LOCATION	CHAR	ASH	SOOT
<b>SAMPLES (Positive)</b>	<b>368</b>	<b>37</b>	<b>4</b>
<b>SAMPLES (%)</b>	<b>17.9%</b>	<b>1.8%</b>	<b>0.2%</b>
Window Sills	39.7 %	2.6 %	0.6 %
Exterior Surfaces	38.5 %	5.8 %	0.6 %
Interior Surfaces	14.3 %	1.2 %	
Attic Surfaces	9.0 %	1.2 %	
Return Plenums	4.4 %		
Clothing	1.5 %		

Ash and Soot: Detection frequency too low  
to be useful for assessment

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## Ranges of %-Char for 199 Impacted Houses\*

%-CHAR	Exteriors	Attics	Window Sills	Interiors
<b>SAMPLES</b>	132	31	136	49
1% - 2%	0.8%	3%	56%	55%
3% - 5%	19%	26%	14%	12%
>5% - 10%	18%	13%	0.7%	0%
>10%	61%	58%	29.4%	26.5%
<b>Range &gt;10%</b>	15% - 80%	15% - 60%	15% - 90%	15% - 99%

\*Second Study

**55% of samples collected from interior surfaces, potentially those most likely to be used to assess impact, had an AVERAGE char concentration of 1%-2% [less than 3%].**

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## 2011 Wildfire Study\* (Graduate Thesis)

- **64 houses** potentially exposed to a 2011 wildfire
- Distances 6-60 miles, Elapsed times 3-8 months
- Alcohol **wet wipe sampling method** was used
  - **Composited 3 interior surface samples**
  - **Average %-char was reported for each house**
- **Ash was not reported in any of the 64 houses, similar to the two studies of 48 and 343 houses**
- **The %-char was less than 1% in 22% of the 64 houses**
- Ward T (2014) “Evaluating the Use of Indoor Residential Wet Wipe Samples Following a Wildfire”; *Intermountain Journal of Sciences*; 20(1), 1-3.

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## Background Char

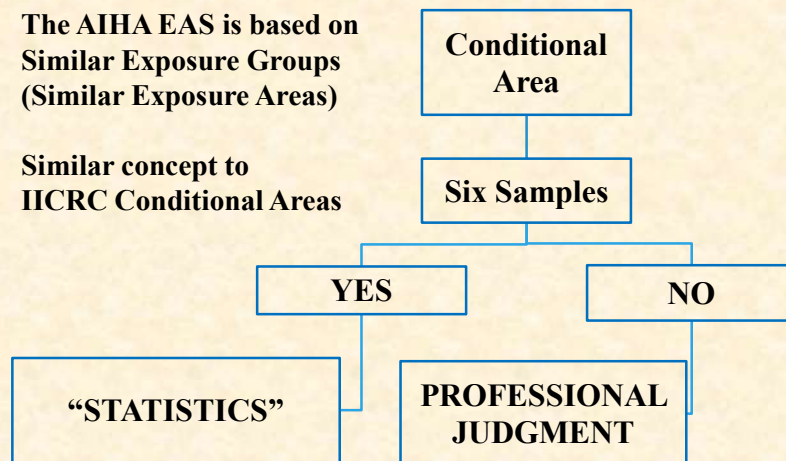
- There are no consensus guidelines for background concentrations of wildfire smoke residues. However,
- The houses included in these three studies were selected from houses potentially exposed to wildfire plumes
  - So background concentrations of char were expected to be higher than in the general housing stock, not lower
- Same confounding factors present (fireplaces, etc.)
- Char was detected at less than 1% in 41% of 455 houses
  - 63% of the 48 houses in the 1<sup>st</sup> Study
  - 42% of the 343 houses in the 2<sup>nd</sup> Study
  - 22% of the 64 houses in Ward's study

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## AIHA Exposure Assessment Strategy

The AIHA EAS is based on Similar Exposure Groups (Similar Exposure Areas)

Similar concept to IICRC Conditional Areas



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## Sampling Locations Were Conditional Areas

- 149 houses in which char was detected on either interior window sills or interior hard surfaces
- Asking if we could predict %-char

On Surface	By Sampling	R-Value
Hard Surfaces	Window Sills	0.23
Attic Surfaces	Window Sills	0.17
Exterior Surfaces	Window Sills	0.37
Exterior Surfaces	Attic Surfaces	0.21

Could maybe do this if  $r = 0.9$  or higher

**IMPORTANT RESULT !!**

- **Conclusion: Could not use %-char from one sampling location to evaluate the impact of char for other sampling locations**
  - Six sampling locations were each separate Conditional Areas
  - Each sampling location was an independent Similar Impact Area

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## Similar Impact Areas (SIA) Similar Restoration Areas (SRA)

- **Conditional Areas may be defined differently in the inspection and restoration phases**
- **Inspections and Restorations have different objectives**
  - We sample interior windowsills and hard surfaces
  - We restore living rooms and dining rooms
- **Objective of using Conditional Areas**
  - **Link the inspection results to the Restoration Work Plan**
    - Allocate resources more efficiently, and where needed most (by area rather than structure)
- **Results for each SIA can be summarized to define**
  - **Similar Restoration Areas in the Restoration Work Plan**

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## Selecting Sampling Methods

- *Investigators must exercise professional judgment, evaluate the analytical methods available, consider the hypotheses in question, develop a sampling plan, and select a method that is appropriate to the situation, purpose of the study, and scope of work.* [AIHA Wildfire Technical Guide, P. 10]
- *“After consultation with the laboratory, the investigator should request the type of analysis which meets the objectives of the investigation.”* [AIHA Wildfire Technical Guide, P. 7]

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## What Is The “Preferred” Method for Sampling Wildfire Smoke Residues?

- AIHA Wildfire Technical Guide, Page 7, “Tape Lifts”, Par 1
  - *“Tape lift samples are preferred for evaluating char, ash, soot ...”*
- Dr. Mirica, EMSL Laboratories: Wildfire Samples
  - Samples submitted for analysis in 2022

FACILITY	Cinnaminson	Pasadena	AVERAGE
Wipes	80%	70%	75%
Tapes	10%	25%	18%
Micro-vac	10%	5%	7%
Swab	0%	0%	0%

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## Comparison of Methods

- **Sampling and analytical methods should be compared using a standardized format that includes relevant parameters**

PARAMETER	TAPE LIFT	WIPE	MICRO-VAC
Sample Area	Defined	Template	Template
Surface Contour	Flat	Intricate	Intricate
Analyte Positioning	Good	Poor	Poor
Collection Efficiency	Adhesion; Dust Layer	Good	Good
Obscuration, Debris	As Collected	Dispersed	Dispersed
Homogeneity, Analy	As Collected	Dispersal	Dispersal
Analysis	Optical methods, SEM (adhesive limits RI)	Optical methods, TEM, SEM/EDX, spectrometric, chromatographic	Optical methods, TEM, SEM/EDX, spectrometric, chromatographic

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## Selecting A Sampling Method

- *“The choice of sampling and laboratory methods should be consistent with the objectives, sampling plan, site-specific conditions, and constraints of the project; and should be directed by professional judgment”.*

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**“Bull Rider”**



**Boeing 737 fuselage after a fullscale fire test**

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