Determination of Particulate Emission Rates from Leaf Blowers

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Overview of Presentation

- Introduction and Objectives
- Approach
- Method Validation
- Results
- Conclusions
- Acknowledgements

Introduction

- PM is Responsible for Adverse Health Effects and Many Airsheds Exceed the Federal AQ Standards
- Accurate Inventories are Needed to Formulate Effective Mitigation Measures
- Leaf Blowers are an Obvious Source of PM Emissions
- Leaf Blow PM Emissions are of a Fugitive Nature and Difficult to Quantify
- No Emission Measurements of PM From Leaf Blowers Have Been Reported

Objectives

- **Develop a Method to Measure Leaf Blower PM Emissions**
- **Validate the Method**
  - **Develop a surrogate debris for comparisons under controlled conditions**
- **Measure PM Emissions from Different Types of Leaf Blowers**
  - **Gasoline-powered**
  - **Electric-Powered**
  - **Rakes**
  - **Brooms**
- **Measure PM Emissions from Different Types of Substrates**
  - **Asphalt**
  - **Concrete**
  - **Grass**
  - **Soil**

Approach

- Enclose the Emission Process
- Monitor PM with Real-Time Sensors Until PM Concentrations Stabilize
  - Compare Results from Real-Time Sensors with filter-based PM Measurements
- Calculate Emission from the Area Blown (Swept or Raked) of Debris, the Tent Volume, and the PM Concentration

Enclosure Construction Design Criteria

- Large Enough to Conduct the Process
- Lightweight to Move Easily Within a Location
- Easily Disassembled to Move to Locations
- Low Cost

Enclosure Design

Monitoring Instrumentation

- **Thermo Systems Inc. Model 8520 DustTrak for Real-Time PM Measurements**
  - Based on light scattering
  - Inlets for TSP, $POM_{2.5}$, PM_{10}
  - 1ug/m^3 Sensitivity
- **Custom Filter Sampler**
  - Greasby Andersen model 246B Inlet for PM_{10} at 16.7 L/min
  - Sensidyne model 240 cyclone for $PM_{2.5}$ at 115 L/min
  - Pall Teflo filters
- **RAE Systems ppbRAE Hydrocarbon Analyzer for Tracer Gas Concentration Measurement**
- **PC-based Labview Data Collection**

Surrogate Debris Development

- Follow UC Riverside Gardening Crew
- Select 1m^2 Collection Area
- Collect All Debris by Sweeping and Vacuuming
- Sieve Debris and Weigh
- 28 Samples Collected

Debris Collection

Samples acquired from UCR prior to leaf blowing



Samples acquired from UC Kearney agricultural facility adjacent to location test chamber placed



Debris Collection Results

Size Range	Average Mass, g	Std Deviation, g
Total Mass	48	77
> 3/8 in	5	6
<3/8 in, >#4	5	6
<#4, >#18	14	28
<#18, >#40	10	17
<#40, >#200	11	23
< #200	3	7

Surrogate Composition

- 120g Soil Sieved Through a #40 screen
- 60 g Leaves
- 60 g Clippings

Method Validation

- Determine Homogeneity
  - Horizontal
  - Vertical
- Determine Mixing Time
- Measure Exchange Rate (with tracer gas)
- Determine Variability

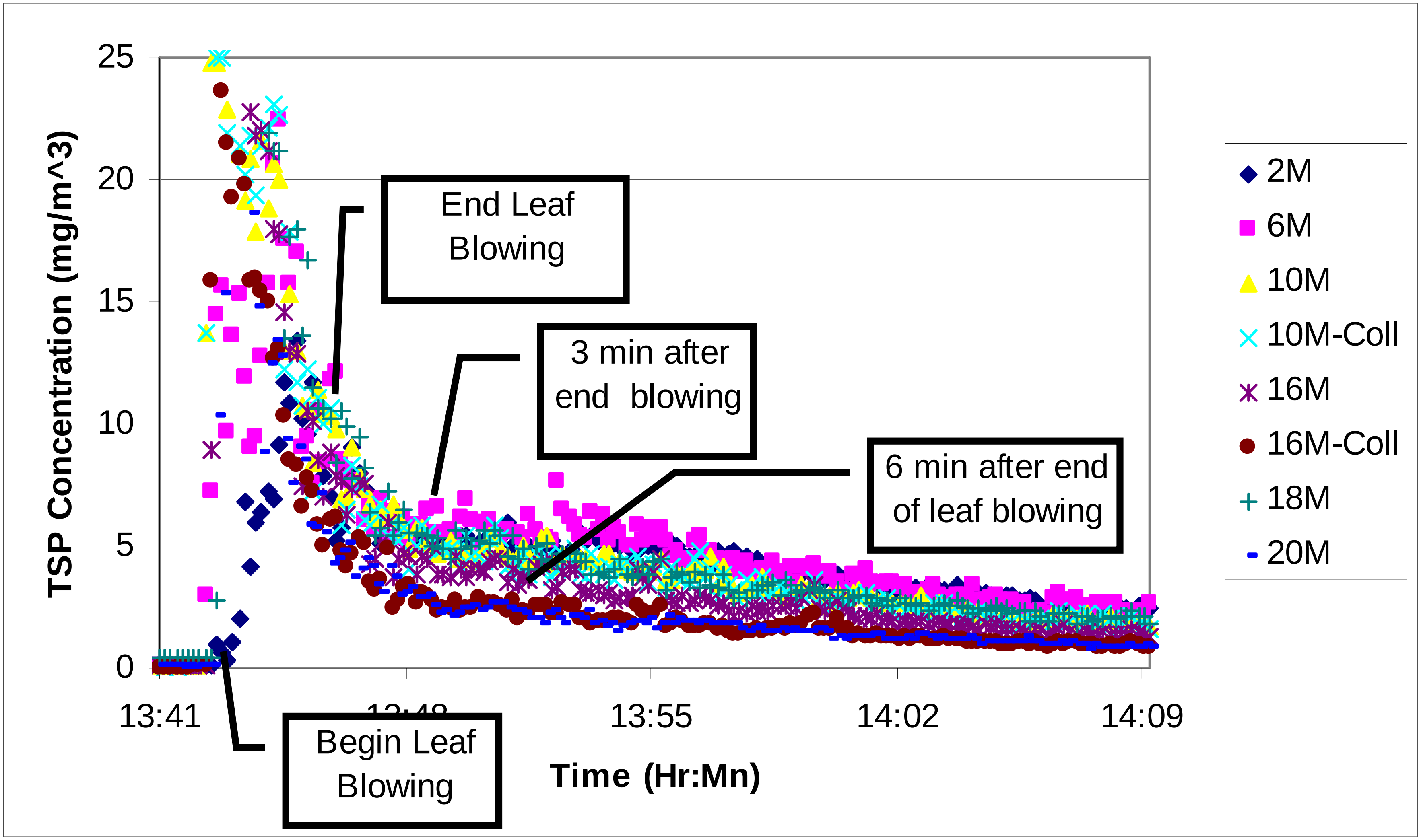
Horizontal Homogeneity Evaluation

- DustTrak Height 2m
- DustTrak at Distances of 2, 6, 10, 16, and 20m from Enclosure Entrance
- Collocated DustTraks at 10 and 16m
- Separate Tests for TSP, $PM_{2.5}$, PM_{10}

Horizontal Homogeneity Testing

Horizontal Homogeneity Testing

Time Series of DustTrak TSP For Horizontal Homogeneity Evaluation



Horizontal PM Concentrations at 6 Minutes

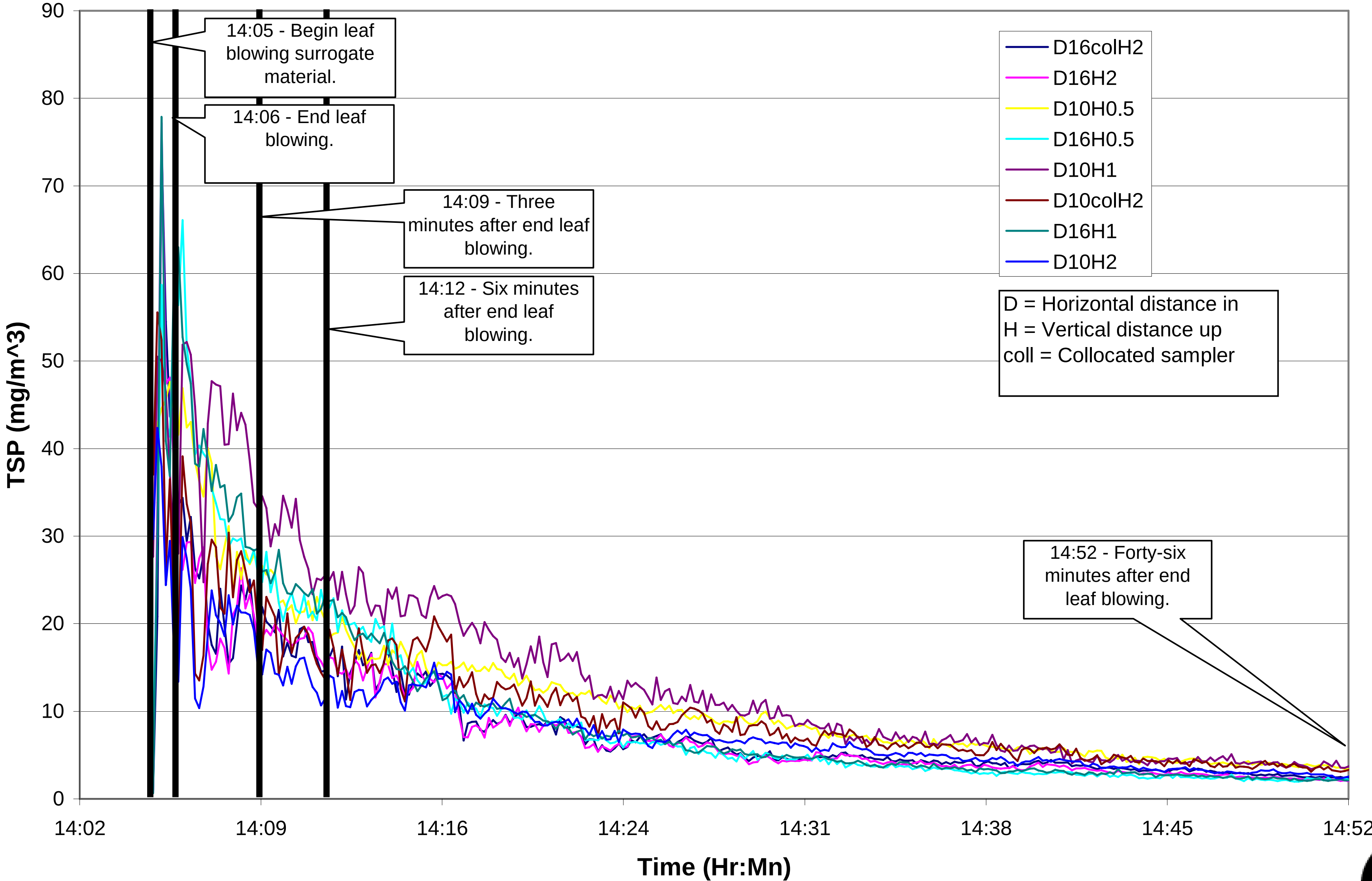
Run	Size	21976 2 Meters	21975 6 Meters	85200674 10 Meters	21569 10 Meters	85200677 16 Meters	21955 16 Meters	21668 18 Meters	21667 20 Meters
0819_1	PM2.5	1.7	1.9	2.4	2.6	2.8	2.2	3.4	3.7
0819_2	PM2.5	2.5	1.7	2.3	2.6	4.1	3.0	5.1	5.2
0819_3	PM2.5	1.7	1.3	1.6	1.5	2.0	1.7	2.6	3.6
0817_1	TSP	2.9	3.7	2.5	2.4	2.8	3.7	2.0	1.6
0817_2	TSP	4.5	5.3	3.9	3.6	3.6	4.4	2.7	1.9
0817_3	TSP	5.6	6.8	4.4	4.2	4.3	4.1	3.6	2.6
0818_1	PM10	7.1	9.9	5.6	8.9	6.9	6.5	4.8	9.4
0818_2	PM10	5.1	7.5		8.0	6.1	5.2	6.1	4.9
0818_3	PM10	5.7	6.4	4.7	7.4	6.3	5.9	5.7	5.0

Conclusion: Less than 12% Error if sampled at 10 and 16m

Vertical Homogeneity Evaluation

- DustTrak Heights of 0.5, 1.0 and 2.0 m
- DustTrak at Distances of 10 and 16m from Enclosure Entrance
- Collocated DustTraks at 2m height, 10m Distance
- Separate Tests for TSP, $PM_{2.5}$, PM_{10}

Time Series of DustTrak TSP For Vertical Homogeneity Evaluation



Vertical PM Concentrations at 6 Minutes

Run	Size	Distance 6			Distance 16				
		Height 0.5M	Height 1M	Height 2M	Height 0.5M	Height 1M	Height 2M	Height 2M	Height 2M
0902_1	PM10	6.0	6.9	4.9	18.6	18.4	20.0	20.6	17.2
0902_2	PM10	4.7	5.8	4.1	22.0	22.9	25.7	24.1	20.0
0903_3	PM10	9.5	11.1	9.0	12.6	12.0	11.1	11.1	9.9
0902_4	PM2.5	2.3	3.9	3.4	1.4	1.9	3.2	3.2	2.1
0902_5	PM2.5	1.6	3.3	2.7	0.9	1.8	2.5	2.9	2.0
0902_6	PM2.5	1.9	2.2	2.3	1.9	1.9	2.0	2.5	1.8
0902_7	TSP	9.6	11.7	11.8	13.3	9.1	7.5	8.1	7.9
0902_8	TSP	7.8	11.5	11.6	11.3	8.5	8.6	9.8	9.3
0902_9	TSP	7.7	9.6	9.5	13.5	7.3	8.1	9.0	8.9

- **Conclusion: Some Variation but Within Measurement Uncertainty**

Results

- **85 Tests Using Surrogate Material**
- **35 Tests on Indigenous Surfaces**
- **6 Devices Used**
- **Two Locations**
- **Emissions Calculated Using the Following Equation:**

$$EF = [(C_{10ave,t=6} + C16_{ave,t=6})/2) \times V_{chamber}] / A_{debris}$$

Summary of PM Emission Results

Cleaning Action and Surface Cleaned	Number of Tests Performed	Type of Emission Factor Obtained from Tests	Emission Factors PM 2.5 (mg/m^2)	PM10 (mg/m^2)	TSP (mg/m^2)
Power Blowing or Vacuuming over concrete surfaces	12	Average emissions from leaf blowing	30	80	100
Power Blowing or Vacuuming over asphalt surfaces	21	Average emissions from leaf blowing	20	60	80
Push Broom on Asphalt Surface	3	Average emissions from sweeping	0	20	30
Push Broom on Concrete Surface	3	Average emissions from sweeping	20	80	110
Raking on Asphalt Surface	1	Average emissions from raking	0	0	0
Raking on Concrete Surface	3	Average emissions from raking	0	0	10
Raking Lawn	1	Average emissions from raking	0	1	1
Power Blowing Lawn	3	Average emissions from leaf blowing	1	2	3
Power Blowing Gutters	3	Average emissions from leaf blowing	9	30	50
Power Blowing Packed Dirt	1	Average emissions from leaf blowing	80	120	160
Power Blowing Cut Grass on Walkway	2	Average emissions from leaf blowing	2	6	9
Breakdown of Emissions by Power Blower Type on Asphalt and Concrete Surfaces					
Elec.Blower	4	Asphalt/CECERT	20	60	80
Gas Hand Held	3	Asphalt/CECERT	10	40	50
Gas Backpack	4	Asphalt/CECERT	20	60	80
Elec.Blower-Vac Mode	3	Asphalt/CECERT	40	120	150
Elec.Blower-Vac Mode - bag full	3	Asphalt/CECERT	20	70	90
Elec.Blower	4	Asphalt/Kearney	0	20	30
Elec.Blower	3	Concrete/CECERT	40	130	170
Gas Hand Held	3	Concrete/CECERT	10	40	50
Gas Backpack	3	Concrete/CECERT	30	70	70
Elec.Blower-Vac Mode	3	Concrete/CECERT	30	80	90

Conclusions

- Soil Origin Made Little Difference in PM Emissions
- Leaf Blower Types All Produced Similar PM Emissions
- Leaf Blower PM Emissions Were Somewhat Lower on Asphalt Than on Concrete Surfaces
- Raking Produced Negligible PM Emissions
- Broom Sweeping PM Emissions on Concrete Were Similar to Leaf Blower PM Emissions
- Broom Sweeping on Asphalt Produced Lower PM Emission Than on Concrete
- Precision is Approximately 19% for $PM_{2.5}$ and 27% for PM_{10}

Conclusions

- **Filter-Based Measurements Agreed to With 50%**
- **This Approach Could be Adapted to Many Types of Fugitive Dust Generating Devices**

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Disclaimer

- **The statement and conclusions in the Report are those of the contractor and not necessarily those of the San Joaquin Valley Unified Air Pollution Control District. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.**