Bay Area Air Quality Management District
CARE Task Force Meeting
June 9, 2005

Sources of Bay Area Fine Particles

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Determining the Sources of Bay Area Particulate Matter (PM)

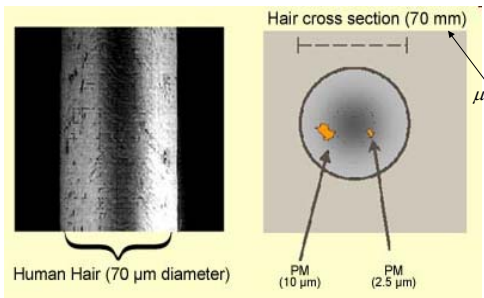
Analysis of existing information

- Analysis of chemical measurements of filters loaded with ambient PM available from existing studies
- Combining with Emissions Inventory to estimate contributions from more specific sources

Studies to fill information gaps

- Carbon-14 analysis
- Organic speciation analysis

Ambient Particulate Matter – Small particles can penetrate far into the lungs

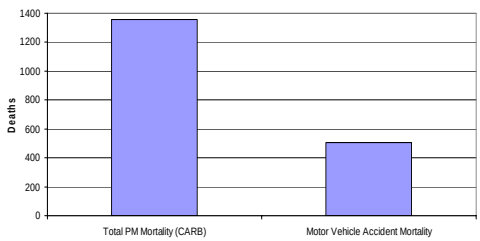


Motivation: PM Health Effects

Range of serious health effects up to and including mortality:

- Asthma exacerbation
- Chronic bronchitis
- Hospitalizations – respiratory and cardiovascular
- Mortality – respiratory, cardiovascular, lung cancer

Estimated Annual Mortality from PM2.5 in the SF Bay Area Compared with Deaths from Motor Vehicle Accidents (2000)



Bay Area Attainment Status for California and National PM Standards

	California Standard	*National Standard*
PM10 – Annual	*Nonattainment*	*Attainment*
PM10 – 24-hour	*Nonattainment*	*Unclassified*
PM2.5 – Annual	*Nonattainment*	*Attainment*
PM2.5 – 24-hour	*No standard*	*Attainment*

Goal

Estimate the contributions of various sources to Bay Area PM2.5:

- Through direct emissions (woodsmoke, motor vehicle exhaust, road dust, ...)
- Through secondary PM, that is, particles that form from gases in the atmosphere (e.g., ammonia and NOx undergo chemical reactions to form ammonium nitrate)

Two Approaches to Estimating PM Sources

Emissions Inventory:

+ Relatively complete set of sources
- May not reflect ambient concentrations. Doesn't include secondary PM.

Chemical Mass Balance (CMB) -- Apportionment using ambient PM filters:

+ Reflects actual PM. Includes secondary PM.
- Set of sources limited. Can't distinguish among some sources.

CMB Analysis

Start with:

Chemical measurements of the PM on an ambient filter. Similar measurements on a range of sources.

Basic idea:

Find the mix of sources that best represents the PM on the filter, measurement by measurement.

Available PM2.5 Speciation Studies

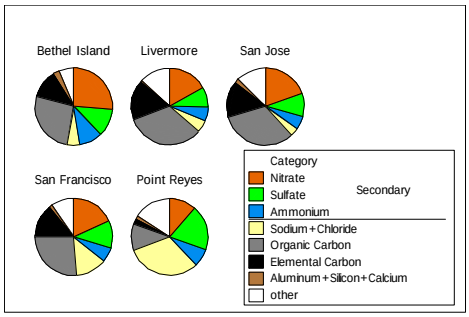
- California Regional Particulate Air Quality Study (Bethel Island, Livermore, San Francisco)
- Speciated Trends Network (San Jose)
- Interagency Monitoring of Protected Visual Environments (Point Reyes)

Chemical Species Measured

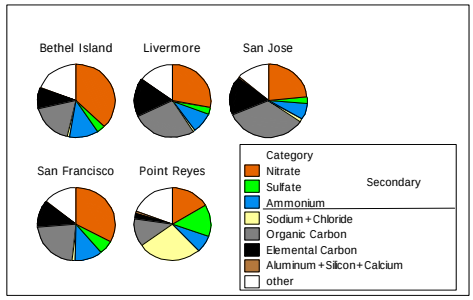
- Array of higher molecular weight elements: from Aluminum through Zirconium (Sodium through Uranium, by mol. wgt.)
- Ions: Nitrate, Sulfate, Ammonium, Sodium, Chloride, Soluble Potassium
- Carbon: Elemental and Organic

You can observe a lot just by watching.
– Yogi Berra

Bay Area Annual PM2.5 Species
% of Total



Bay Area Peak PM2.5 Species
% of Total



Sources Used in CMB Analysis

Directly Emitted:	***Secondary:***
• Road dust	• Ammonium nitrate
• Motor vehicle exhaust	• Ammonium sulfate
• Tire & brake wear	
• Wood smoke	
• Meat cooking	
• Marine air (sea salt +)	

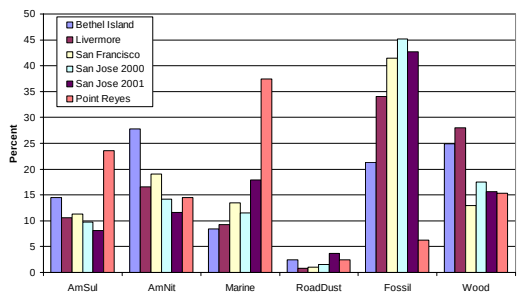
Minor Sources
(according to CMB)

Meat cooking – could not be differentiated from other carbonaceous sources

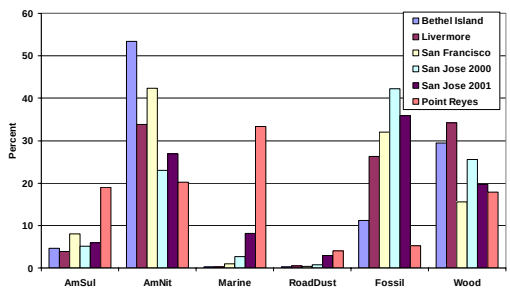
Tire/Brake wear – did not appear as a significant source

➔ CMB rerun without these sources

Annual PM2.5 Contributions (%)
CMB Estimates



Peak PM2.5 Contributions (%)
CMB Estimates



Some Conclusions About Bay Area PM2.5

- Ammonium nitrate is a large contributor to both annual and peak PM2.5
- Ammonium sulfate is a significant contributor to annual PM2.5 but not peak
- Road dust/geological dust/brake&tire wear are insignificant sources of PM2.5 in the Bay Area
- Most PM2.5 derives from combustion

Combining CMB Results with the Emissions Inventory

- CMB modeling provides information on source *categories* rather than individual sources

➔ Can combine with Emissions Inventory to estimate contributions from more specific sources

➔ Can factor in contributions to secondary PM from NOx and SO2

Some assumptions:

- Emissions of SO2 proportional to contributions to ammonium sulfate
- Emissions of NOx proportional to contributions to ammonium nitrate

Estimated % Total Contribution to Annual PM2.5 from Various Sources

	CMB Source Category:						
Inventory Source:	Amm. Sulf.	Amm. Nitr.	Mar-ine	Road Dust	Fos-sil	Wood burn.	Totals*
Wood burning	0	1				18	19
Cooking	0	0			5	3	7
On-Road	0	10		1	7		18
Off-Road	3	6		0	14		23
Refining	6	1			4		11
Power Plants	0	1			2		3
Aircraft	0	1			3		4
Marine Air			11				11
Other	2	1	0	0	0	0	3
Totals*	12	19	11	1	35	21	99

**Terms may not add to totals due to rounding.*

Estimated % Total Contribution to Peak PM2.5 from Various Sources

	CMB Source Category						
Inventory Source:	Amm. Sulf.	Amm. Nitr.	Mar-ine	Road Dust	Fos-sil	Wood burn.	Totals*
Wood burning	0	1				23	24
Cooking	0	0			4	4	7
On-Road	0	19		0	6		25
Off-Road	2	11		0	11		24
Refining	3	2			3		8
Power Plants	0	1			2		3
Aircraft	0	1			3		4
Marine Air			1				1
Other	1	2	0	0	0	0	3
Totals*	5	38	1	0	28	26	99

**Terms may not add to totals due to rounding.*

Additional Conclusions About Bay Area PM2.5

- Suggests on-road and off-road combustion directly or indirectly contribute nearly 50% of Bay Area PM2.5
- Wood smoke is the other large source, contributing at least 20% on an annual basis and 25% to peak PM2.5
- Other substantial sources include refineries, commercial cooking, aircraft, and power plants
- Almost all Bay Area PM2.5 derives directly or indirectly from combustion

Gaps in our Knowledge and Studies to Address them

(1) Large uncertainties in distinguishing fossil combustion sources from those of wood/cooking

➔ ***Carbon-14 analysis***

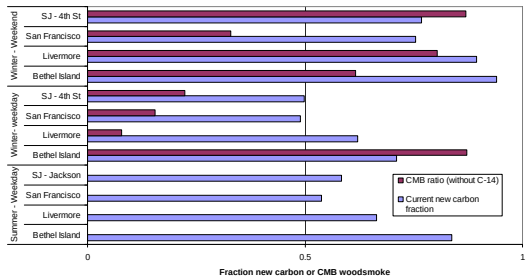
(2) Not possible to distinguish between woodsmoke and cooking; or among diesel, gasoline, and other fossil fuels

➔ ***Organic carbon analysis***

Carbon-14 Analysis

- C-14 is a radioactive isotope of carbon constantly being created by cosmic rays in the upper atmosphere. It gets incorporated into living plants and animals.
- C-14 has a half-life of about 5,000 years, so that millions of years old fossil fuels have no C-14 left
- Thus C-14 analysis can differentiate between "new" carbon (woodsmoke, cooking, wildfire) and "fossil" carbon (gasoline, diesel, natural gas)

Preliminary Carbon-14 Results & Comparison with CMB



Additional Carbon-14 Analysis (in progress)

- 2004 PM10 filters from all BAAQMD sites are being analyzed for Carbon-14 by the University of Arizona
- For each site, filters from a representative sample of days throughout the year are being composited to yield an estimate of the amount of new and fossil carbon on an annual basis

Organic Carbon Speciation

- The District is contracting with Desert Research Institute to speciate organic carbon for a range of PM2.5 filters collected at San Jose – Jackson Street site
- Potential to identify individual sources using organic markers, such as
  - meat cooking (cholesterol, alkenoic acids),
  - motor vehicle emissions (hopanes and steranes from motor oil),
  - wood smoke (levoglucosan, resin acids),
  - secondary organic aerosol (alkanedioic acids)
- No unique marker for diesel
- Will use CMB analysis on organic measurements (plus the more traditional measurements)