PM Emissions from Chip and Bark Piles
Preliminary NCASI Work

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Storage Pile PM Emissions

- Facilities are increasingly being called upon to model impacts of PM2.5 emissions

- PM10 & PM2.5 emissions from storage piles can have an outsized impact on modeled fenceline concentrations relative to emission rate
  - Low elevation, ambient & area source
  - Function of size of piles and location relative to modeled impact points

- Fugitive sources have traditionally not been focused on to the degree of larger stack sources

Emission impacts are often already captured in background concentrations

Storage Pile PM Emissions

- Emissions must be estimated by empirical methods
  - Typically developed from test data for coal, sand or gravel
  - Estimates typically yield TSP emissions

$$EF_{PM10} = k_{PM10}\, EF_{TSP} \qquad EF_{PM2.5} = k_{PM2.5}\, EF_{TSP}$$

  - k_{PM10} and $k_{PM2.5}$ are not presented for wood or bark

- Emissions sources:
  - Material handling (loading & unloading)
  - Wind erosion
  - Vehicle traffic

Material Handling - Unloading

- AP-42 Chapter 13.2.5 (1987)

$$EF = 0.0032 \frac{\left(u_{Mean}/5\right)^{1.3}}{\left(M/2\right)^{1.4}} \left(\frac{lb\ TSP}{ton\ of\ material}\right)$$

- AP-42 - Supplement 14 (1984)

$$EF = 0.018 \frac{\left(s/5\right)\left(u_{Mean}/5\right)\left(h/10\right)}{\left(M/2\right)^{2}} \left(\frac{lb\ TSP}{ton\ of\ material}\right)$$

Wind Erosion

- AP-42 Chapter 13.2.5 (1988)

$$EF = \sum_{i}^{N} P_i$$

$$P = 58\left(u^* - u^*_t\right)^2 + 25\left(u^* - u^*_t\right)\left(\frac{g\ TSP}{m^2}\right)$$

- AP-42 - Supplement 14 (1984)

  (for continuously active piles)

$$EF = 1.7\frac{s}{1.5}\frac{d}{235}\frac{f}{15}\left(\frac{lb\ TSP}{day\ acre}\right)$$

Storage Pile PM Emissions

- Estimated emissions increase with
  - Wind speed
  - # of dry days
  - Silt content (fraction of bulk material that is <75 μm)
  - Drop height
  - Lower moisture content
  - Surface area
- TSP emissions must be converted to PM10 and PM2.5

$$EF_{PM10} = k_{PM10}\, EF_{TSP} \qquad EF_{PM2.5} = k_{PM2.5}\, EF_{TSP}$$

- Questions regarding applicability of empirical relations to FP sources:
  - Higher particle density
  - Moisture range: ~0.5 -5.0%
  - Silt range: 1-20%
  - Silt range: 1-20%
  - No threshold friction velocity for wood or bark PM
  - PM fractions

$$k_{PM10} = 0.35 \quad k_{PM2.5} = 0.053$$

Storage Pile PM Emissions NCASI Work

- Preliminary work has been to characterize inputs for emissions estimate methods
  - Silt fractions for chip and bark
  - k_{PM10} and $k_{PM2.5}$
- Chip and bark samples collected from 4 chipping facilities at 3 mills
  - Gross particle size distribution by sieving
  - PM10 and PM2.5 content and characterization by SEM analysis

Chip Pile PM

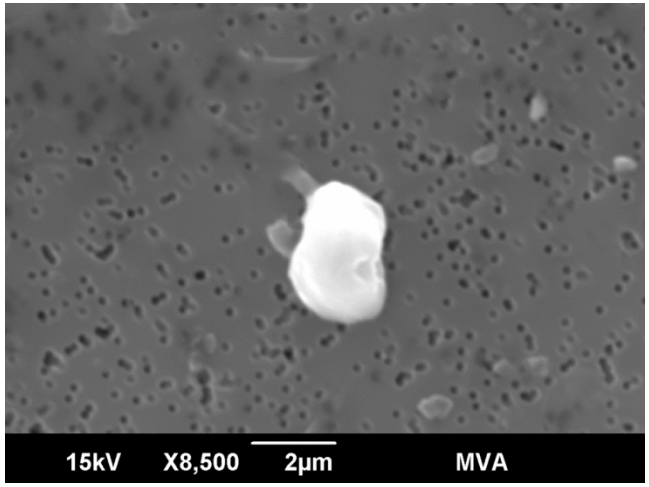
	Notes	Fines (<3 mm)	TSP (<100 μm)	"Silt" (<75 μm)
Mill A	Unclassified, freshly chipped Pine	0.97%	0.00057%	0.00002%
Mill B	Unclassified, freshly chipped Pine	1.82%	0.00052%	0.00004%
Mill C – Offsite	Unclassified, freshly chipped Hardwood	4.22%	0.00129%	0.00049%
Mill C – Offsite	Unclassified, freshly chipped Pine	0.79%	0.00007%	0.00002%
Mill C - Pile	Trucked 25 miles Hardwood	3.55%	0.00125%	0.00037%

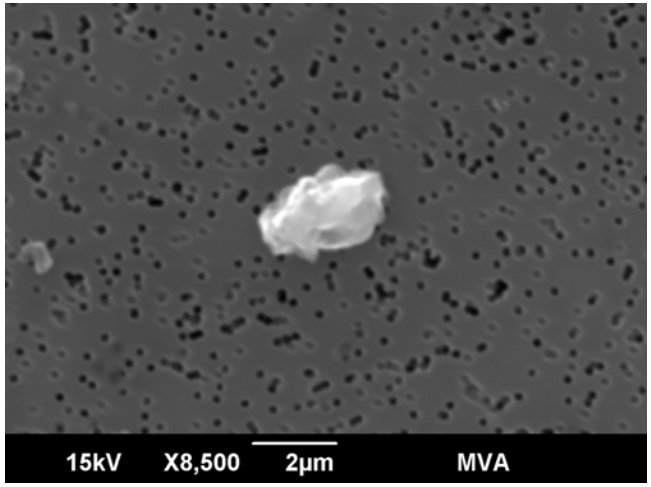
Bark Pile PM

	Notes	Fines (<3 mm)	TSP (<100 μm)	"Silt" (<75 μm)
Mill B	Unclassified, freshly debarked Pine	10.62%	0.010%	0.0022%
Mill C - Offsite	Unclassified, freshly debarked Hardwood	10.00%	0.0071%	0.0024%
Mill C - Pile	Trucked 25 miles Hardwood	11.06%	0.0060%	0.0014%

SEM Analysis at Mill A

- Thirteen individual PM2.5 particles were analyzed
- Chip PM
  - Particulate is a mix of carbon, ash and soil
  - k_{PM10} = 0.0030
  - $k_{PM2.5}$ = 0.0005
  - PM2.5/PM10 = 16.7%
- Bark PM
  - Particulate is a mix of carbon, ash and soil
  - k_{PM10} = 0.0015
  - $k_{PM2.5}$ = 0.0002
  - PM2.5/PM10 = 13.3%





Impacts of Preliminary Results

Chips	s = 0.00019% k_{PM10} = 0.0030 $k_{PM2.5}$ = 0.0005
Bark	s = 0.0020% k_{PM10} = 0.0015 $k_{PM2.5}$ = 0.0002

- Silt content much lower than material in AP42
  - Will impact facilities using alternative estimation methods
  - May be similar issue with road factors
  - No significant impact observed from hauling
- k_{PM10} and $k_{PM2.5}$ are also much lower
  - Will impact all emissions estimates
- None of the PM2.5 observed to be woody or fibrous material

Storage Pile PM Emissions
Future NCASI Work

- Expand chip and bark pile dataset
  - Identify impact of wood species
  - Investigate impacts of transport, storage and handling
  - Collect additional SEM analyses for k_{PM10} and $k_{PM2.5}$
- Evaluate threshold friction velocity for wood and bark "dust"
- Characterize fugitive particulate for source apportionment and background contributions
- Expand fugitives work to facility roads

We are soliciting chip and bark samples

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