Analysis of Particulate Matter in the Macatawa Watershed Air

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Air Pollution and Particulates Overview

- **Air pollution** is the presence of biological matter, particulates, and any other harmful substance expelled into the air.
  - particulates that make up air pollution cause harm to the natural and built environment, as well as to humans.
- **"Particulate matter,"** also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. It is made up of a number of components, including acids, organic chemicals, metals, and soil or dust particles
  - PM2.5 and PM10 refer to the diameter in microns of the particulates.
- The World Health Organization estimates that **particulate matter air pollution results in about 800,000 premature deaths each year,** making it the 13th leading cause of mortality worldwide

Air Pollution and Particulates

- **Major sources of particulate matter**
  - human combustion of fossil fuels
    - coal industry, steel industry, and power generation
  - biomass burning
  - vehicle exhausts
    - diesel, gasoline, and propane
  - pesticides
  - dust, mold, pollen

Figure 1: A comparison of particulate matter sizes in reference to a single strand of hair

Ottawa County Air Quality

- Average of all particulate matter is 27 µg/m³ in Ottawa County, versus 23 µg/m³ as the national average
  - Lake Michigan, topography, and wind pattern have major impacts
  - PM10 particles can stay in the air for minutes or hours can travel as little as much as 30 miles
  - PM2.5 particles can stay in the air for days or weeks, and travel up to many hundreds of miles.
- Early 2000s the county had high PM levels, peaking at 37 ug/m3 in 2005
  - attainment level is 35 ug/m3, set by the EPA
  - In 2008 Ottawa County reached "attainment" levels, and particulate matter levels have not risen above standards on record since 2007
- Particulate matter poses many health risks to the human body

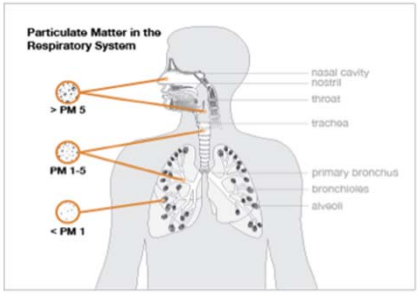


Figure 2: A diagram showing where each size of PM is found most commonly accumulated in the body

Our Project

Our research centered around looking at the variation of particulate matter based on geographic variation from three test sites.

We focused on determining:

1. the **composition** of particulates in the air
2. **concentration**/density of particulates in the air

Methods: Study Sites

Three experimental sites within the Macatawa Watershed

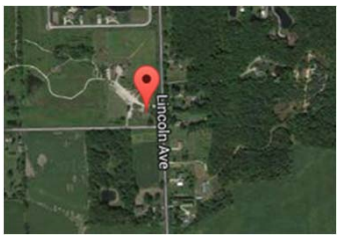
- Each chosen for their relationship to the surround environment.

Schaap Science Center:

- (42.787, -86.105)
- Site near urbanized area
- Many anthropogenic sites near by

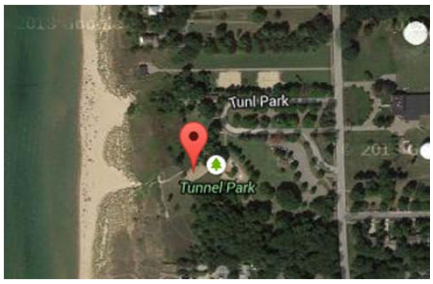
Outdoor Discovery Center:

- (42.726, -86.103)
- Rural area
- Located by agricultural fields and farms



Tunnel Park:

- (42.798, -86.209)
- Shoreline, coastal region



Methods: sample collection

- Altered a Buchner funnel to fit a Stanley Shop Vac
- Whatman 5 filter paper
- Ran vacuums for average of 10 hours
- Added Scotch tape across funnel mouth
- Stored in sterile petri dishes

Figure 3: The experimental set-up replicate for the Schaap Science Center

Methods: processing & analysis data

- Carbon coated samples with a Cressington carbon coater 108
  - reduce charging in the scanning electron microscope
- TM3000 Scanning Electron Microscope was used for analysis
  - obtain the chemical composition of the particulates in the air.
- Measurements were taken using Quantax 50 software on the computer, system
  - performs elemental qualitative and quantitative analyses of materials
  - three rows, twelve frames per row for a total of 36 frames per sample
  - 90 individual particles were analyzed from each sample

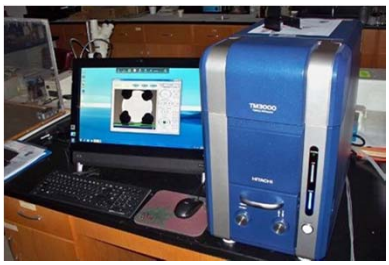
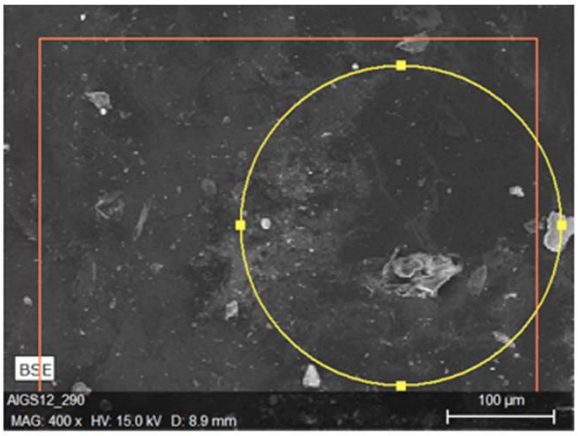


Figure 4: The Scanning Electron Microscope (SEM) at Hope College

Methods: processing & analysis

Output Sample:



Spectrum: Point

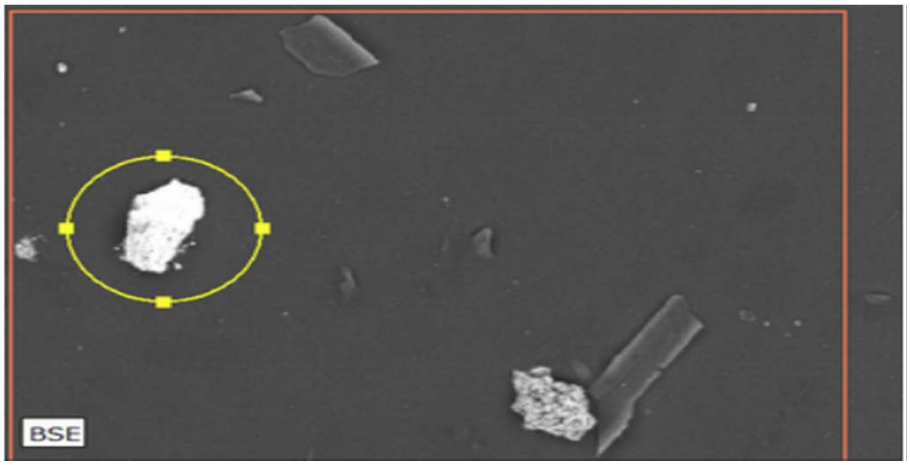
Element	AN	Series	Net	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error [%]
Chlorine	17	K-series	826	0.65	12.37	12.41	0.0
Silicon	14	K-series	756	0.56	10.63	13.45	0.0
Potassium	19	K-series	471	0.56	10.58	9.63	0.0
Sulfur	16	K-series	717	0.50	9.60	10.64	0.0
Calcium	20	K-series	318	0.48	9.08	8.06	0.0
Copper	29	K-series	34	0.41	7.72	4.32	0.0
Zinc	30	K-series	24	0.40	7.69	4.18	0.0
Sodium	11	K-series	309	0.38	7.17	11.09	0.0
Magnesium	12	K-series	369	0.36	6.87	10.06	0.0
Aluminium	13	K-series	324	0.27	5.14	6.78	0.0
Titanium	22	K-series	100	0.23	4.31	3.20	0.0
Iron	26	K-series	35	0.17	3.23	2.06	0.0
Chromium	24	K-series	56	0.17	3.19	2.18	0.0
Scandium	21	K-series	66	0.12	2.20	1.74	0.0
Phosphorus	15	K-series	9	0.01	0.13	0.15	0.0
Vanadium	23	K-series	0	0.00	0.02	0.01	0.0
Manganese	25	K-series	0	0.00	0.02	0.01	0.0
Cobalt	27	K-series	0	0.00	0.02	0.01	0.0
Nickel	28	K-series	0	0.00	0.02	0.01	0.0

Classifications

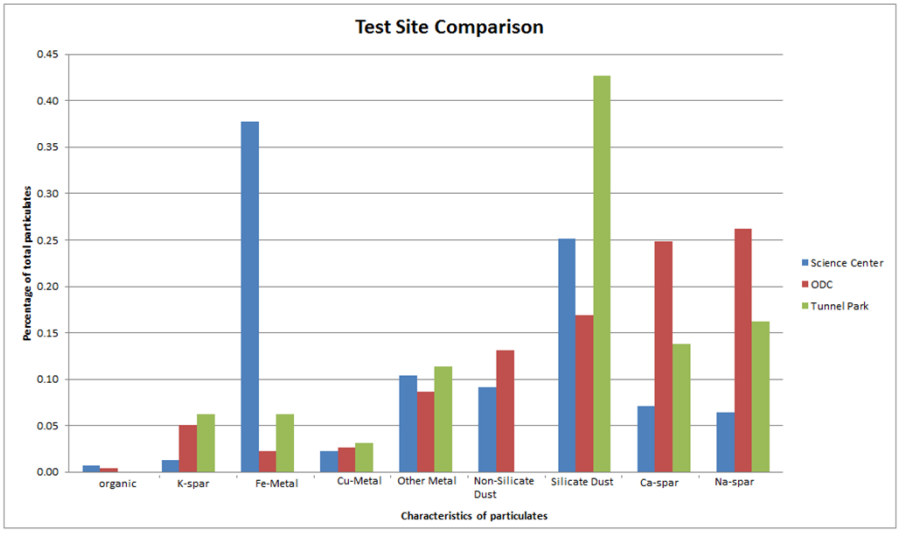
- (Organic)- Absence of elements
- (K) Potassium Feldspar - Mixture of Al, <30% Silicate, >30% Potassium
- (Fe Metal) - Most prevalent element was Iron
- (Cu Metal) - Most prevalent element was Copper
- Low Silicate Dust - <30% Silicate
- Silicate Dust - >30% Silicate
- Calcium Feldspars- Mixture of Al, <30% Silicate, >30% Calcium
- Sodium Feldspars- Mixture of Al, <30% Silicate, >30% Sodium

Identification

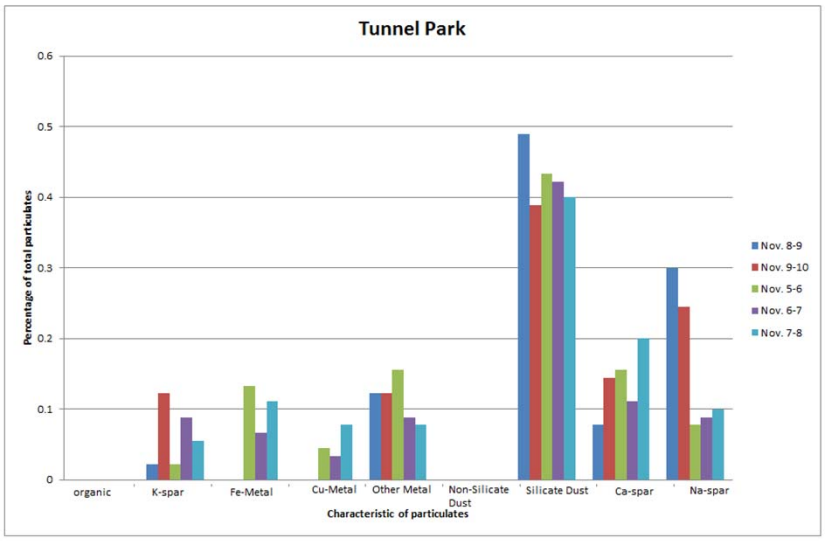
A sample output of a particulate high in iron



Comparison of Sample Sites

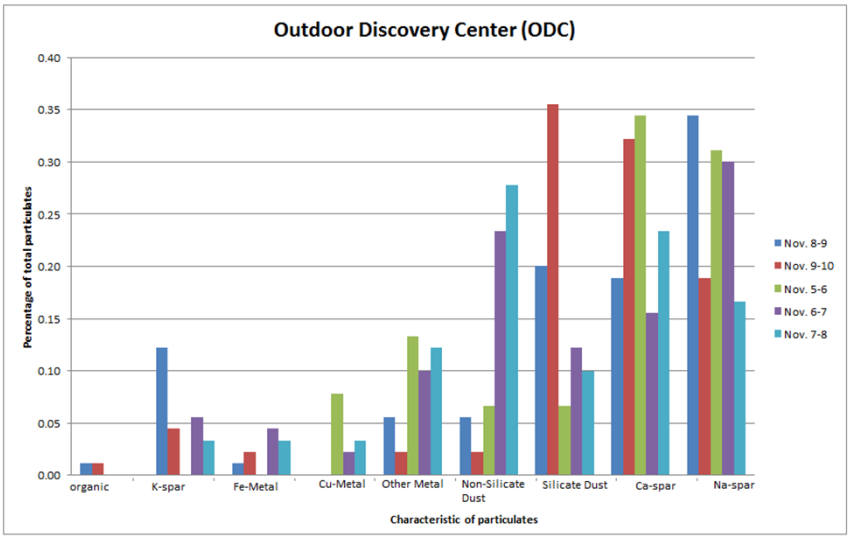


Tunnel Park Sample Analysis



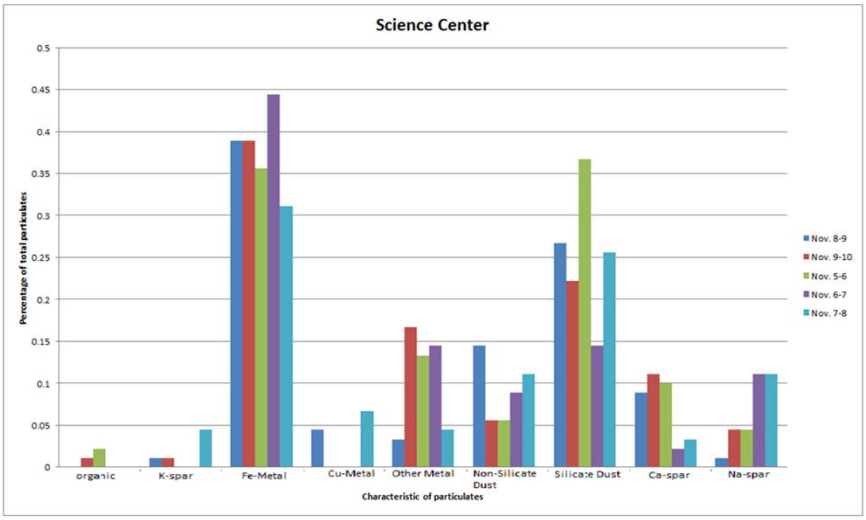
- All five days have a high concentration of silicate dust particles
- The metal concentrations vary throughout the five days, this includes some days having a deficiency in metals
- All five days have concentrations of feldspars, which is typically seen in sand particles and common on the beach front

Outdoor Discovery Center Sample Analysis



- All five days have a high concentrations of feldspar (soil dust) and silicate dust (dunes)
- The metal concentrations vary throughout the five days, this includes some days having a deficiency in metals

Science Center Sample Analysis



- All five days have a high concentration of Fe-Metal particles
- The feldspar concentrations vary throughout the five days, this includes some days having a deficiency in feldspars
- All five days have concentrations of feldspars, silicate dusts, and other metals

What the Data Means

- There is a definite difference in particulate matter from site to site
  - Tunnel Park is high in silicate dust due to the sand
  - Schaap Science Center is quite high in iron due to the close proximity to industrial activity
  - The ODC high frequencies in feldspars is consistent with the amount of soil dust from surrounding agriculture

Future of the Macatawa Watershed Air

- The research is not a closed-circuit study, just preliminary work on air quality
  - We are all affected by air quality, as well as the environment
- Due to the small sampling window, air quality testing should be done during each season in the watershed and more thoroughly analyzed
- Hope College implementing sampling at points within the watershed for lab analysis

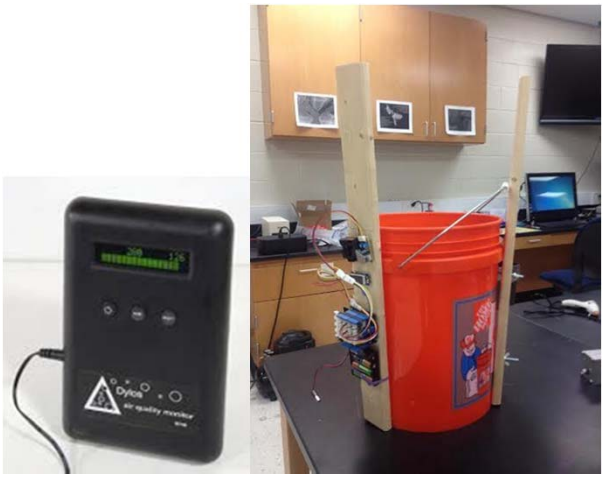


Figure 5: Devices that can be used in residential homes to sample air quality

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