USING X-RAY FLUORESCENCE IMAGING TO ANALYZE METAL CONCENTRATIONS IN AIRBORNE PARTICULATE MATTER COLLECTED IN OUR LOCAL ENVIRONMENT

Particulate Emissions Analysis

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ABSTRACT

- Our experiment focused on the chemical composition of particulate matter; we hypothesized that urban environments would have a higher concentration of transition metals than suburban environments. We collected samples from downtown Chicago, our school's exhaust vents, and a suburban area. To collect our samples, we used MERV-13 filters suspended via a 3-D printed air box fitted around a battery-powered fan. After we collected our filter samples from our airbox we used x-ray fluorescence spectroscopy at the 13-ID-E beamline at the Advanced Photon Source to analyze photon energy levels to determine elemental abundance.

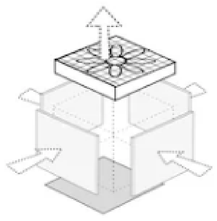
GOALS

1. What elements are present in particulate matter in air from different urban and rural environments around Chicago?
2. Which elements are most common in air from our school?

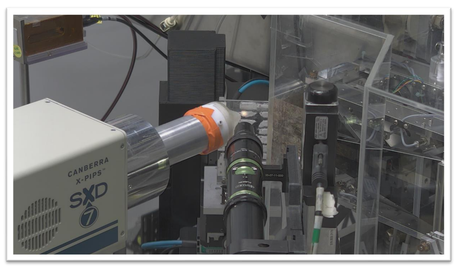
MOTIVATION

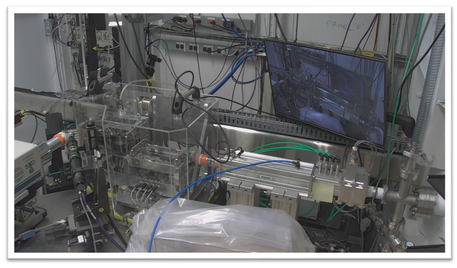
- According to the American Lung Association, the average human breathes 2,000 gallons of air per day [1]. Due to this fact, we wondered, "What composes the air we breathe and what kind of effects could this have on our health?"

PROCEDURE



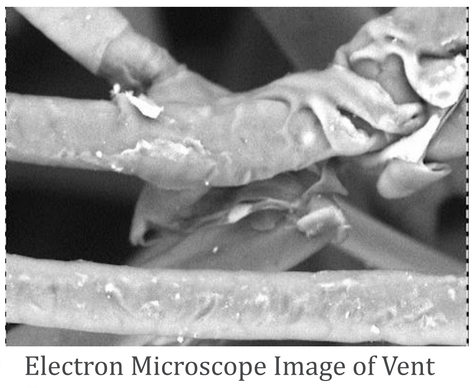
- Airbox build with MERV-13 filters [2].



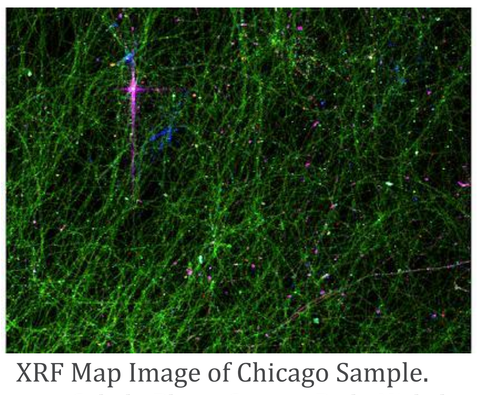


- Experiment beamline 13-ID-E setup

- An airbox is placed at varying locations and a blank sample was taken for control. Constructed out of PLA and MERV-13 Filters, the airbox pulls in surrounding emissions through a propeller fan collecting the particulates. Repeated experiments are conducted to maintain accuracy, account for weather conditions, and other external variables. The samples - Urban, Suburban, Vent-Filtered, Unfiltered, Untested - are weighed and placed in beamline 13-ID-E to conduct X-ray Fluorescence Mapping with a beam size of 10 µm.



- Electron Microscope Image of Vent Filters.



- XRF Map Image of Chicago Sample. Green – Cobalt, Blue – Copper, Red - Nickel

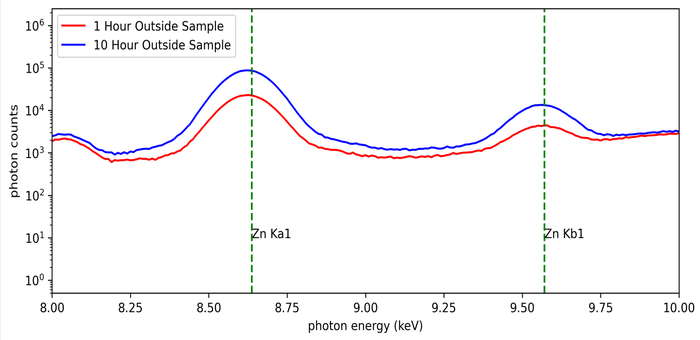
WHY MERV FILTERS

- Airborne particles size between 0.3 to 10 microns (µm). The use of a certified MERV-13 filter collects 85% of airborne contaminates [3].

DATA ANALYSIS

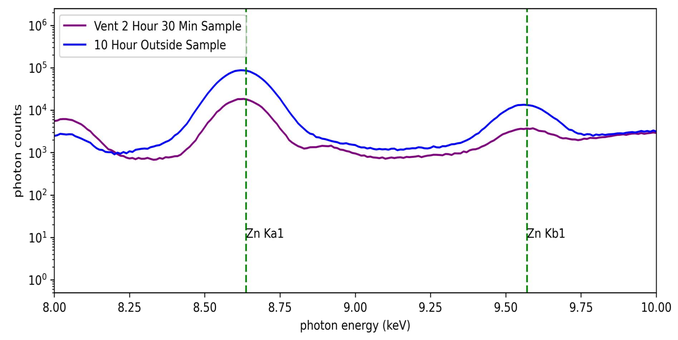
Used GSECARS Mapviewer to fit elemental emission lines and output concentration data.

10 HOUR SAMPLE (2) V 1 HOUR SAMPLE OUTSIDE (1)



The zinc ratio value from the 10 Hour Sample to the 1 Hour Sample is 4.44 +/- 0.07 (1.6%)

10 HOUR SAMPLE (2) V 2 HOUR 30 MIN VENT SAMPLE (3)

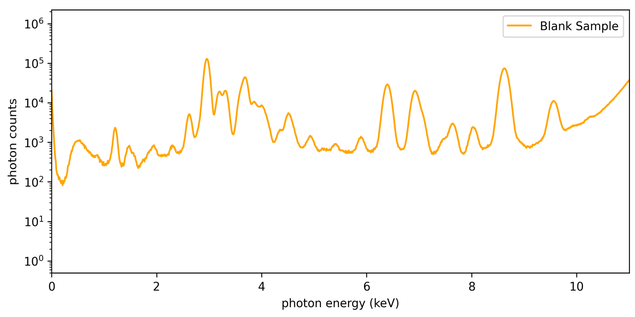


The zinc ratio value from the 10 Hour Sample to the Vent 2 Hour 30 Sample is 4.61 +/- 0.07 (1.6%)

BLANK SAMPLE (5)

Sample (1) It was also placed on a suburban patio for 1 hour.

Sample (2) Air box was first placed on a suburban patio for 10 hours

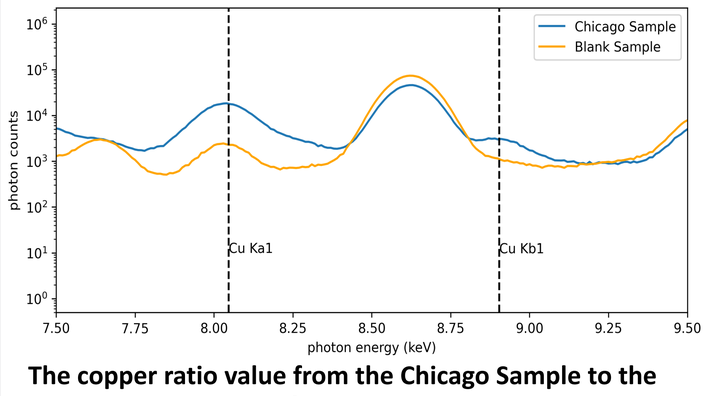


Sample (3) It was also placed near a classroom vent for 150 min.

Sample (4) Air box was placed in a high-rise parking garage and compared with a blank filter.

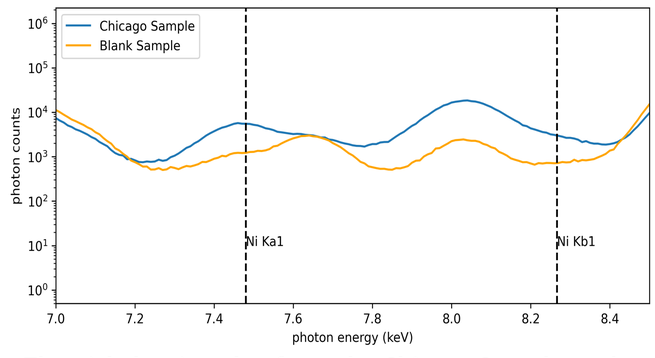
Sample (5) An unused sample of MERV filter paper was a control.

CHICAGO (4) V BLANK SAMPLE (5)



The copper ratio value from the Chicago Sample to the Blank Sample is 2.41 +/- 0.11 (4.6%)

CHICAGO (4) V BLANK SAMPLE (5)



The nickel ratio value from the Chicago Sample to the Blank Sample 3.91 +/- 0.65 (16.7%)

CONCLUSIONS

- Our experiment has suggested that the concentration of transition metals in particulate matter is higher in urban areas than in suburban areas.
- Our graphs where the samples were taken from Chicago show higher concentrations of copper and nickel.
- Our 10-hour outside sample is conflicting with that principle as it contained a higher concentration of zinc. This may have been attributed to the placement of our airbox being in a pot with soil and fertilizer, which is a common product containing zinc.
- These findings have given us a picture of the reasons why the air in urban areas might be harmful to people's health.

NEXT STEPS

- In follow up experiments, we would get better results and stronger conclusions through improving the airbox's design and collecting more samples:
  - The airbox's design would see a new more efficient way to slide the filters into place and be more securely locked in without any chance of contamination.
  - We would also collect more samples at differing locations for varying periods of time. Having samples collected on 1-hour intervals and in various places could result in a higher accuracy for the results.

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