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Field Experience and Capstone Project:

PM10 Sampling on Fort Riley Kansas, Spring 2012

MPH Committee

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PM10 Sampling on Fort Riley Kansas

Spring 2012

Particulate Matter (PM) in Ambient Air

- Common point and non-point sources of PM:

  Refineries, utilities, industrial manufacturing, homes, cars, burning of organic materials, and the environment

- PM sizes considered as health risks to humans: Thoracic Particles (PM_{10}), all particles <10 micrometer (µm). Further defined as:
  - Course particles $PM_{10-2.5}$ (sizes between 10 and 2.5 µm)
  - Fine particles ($PM_{2.5}$), all particles < 2.5 µm
  - Ultrafine particles (UFPs), all particles < 0.1 µm
- Important co-pollutants are Oxides of Nitrogen and Sulfur, Lead, VOCs and semi-VOCs, and CO

Health Considerations in Humans

- "Most, but not all, epidemiological studies corroborate the elevated risk for cardiovascular events associated with exposure to fine PM 2.5 m in aerodynamic diameter (PM2.5). PM2.5 generally has been associated with increased risks of myocardial infarction (MI), stroke, arrhythmia, and heart failure exacerbation within **hours to days of exposure** in susceptible individuals." (Circulation AHAjournals, Brook et al, June 2010)

- "Air pollutants have been linked with endothelial dysfunction and vasoconstriction, increased blood pressure (BP), prothrombotic and coagulant changes, systemic inflammatory and oxidative stress responses, autonomic imbalance and arrhythmias, and the progression of atherosclerosis." (Circulation AHAjournals, Brook et al, June 2010)

Health Considerations in Humans

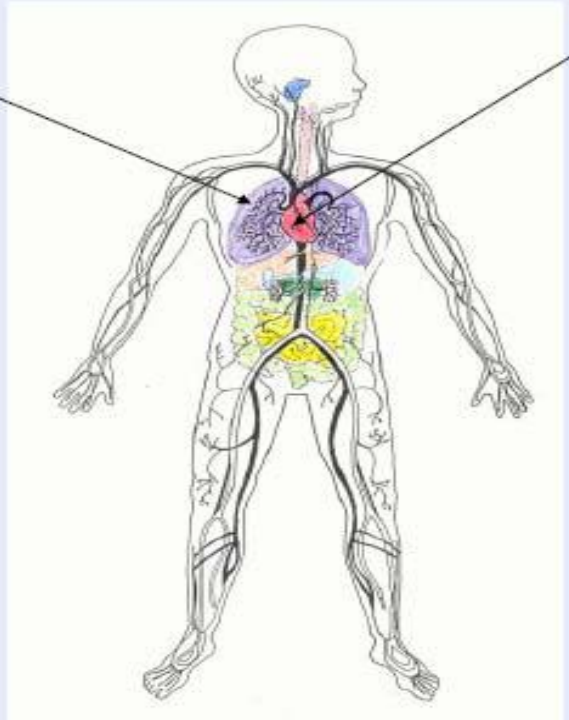
Ozone and PM – Health Effects

Respiratory:

Coughing, wheezing, reduced lung function

Reduced resistance to infection

Aggravation of asthma, emphysema and bronchitis



Cardiovascular:

Inflammation

Heart failure

Cardiac arrhythmia

Hardening of the arteries

Stroke

Heart attack

Health effects of Ozone and PM, (KDHE SMP)

Health Considerations in Humans

- Susceptible individuals:
  - Those with predisposing factors
    - Genetic disposition towards cardiovascular diseases
    - Atherosclerosis
    - Age
    - Metabolic disease, #1 Diabetes
    - Weight
  - All others
- Additional consideration:
  - Primarily, ozone is a contributing factor to respiratory diseases and may also be a contributing factor with the negative cardiovascular effects of PM.

Methods of Project

- **SKC Deployable Particulate Sampler Systems placed at five sites on Fort Riley (SKC Inc., Eighty Four, PA 15330).**
  - **Site #1 Camp Funston ALT = 362’**
  - **Site #2 Marshall Airfield 367’**
  - **Site #3 Main Post 397’**
  - **Site #4 Custer Hill 443’**
  - **Site #5 Camp Forsyth (Units #5 and #6 Co-located) 354’**





Locations

- Each location had unique variables affecting the immediate air quality near the DPS unit.
  - Site #1, Camp Funston was in a working area with periodic use and traffic. It had one of the lowest elevations at 362'. The main traffic flow was >100 meters away.
  - Site #2, Airfield had significant traffic passing by during the hours of 0730 and 1800, seven days a week. The landing zone for the airfield was 300-400 meter way and Interstate 70 was within 1500 meters. This was bottomland ground and flat.

Locations

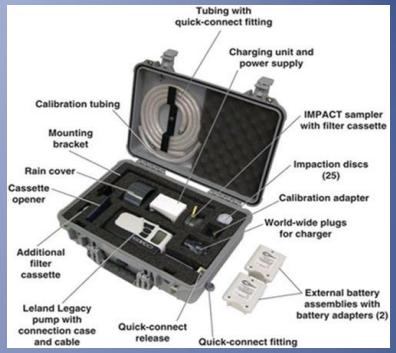
- Location continued:
  - Site #3, Main Post was on a hillside and located near a school. The main traffic lanes were 100 meters + away and there was limited traffic on the access road where the unit was located. This unit was located on a grade school grounds.
  - Site #4, Custer Hill was the highest in elevation (443’). It was located adjacent to a power sub station. It had a larger green space around it and primary traffic routes were >100 meters away. It was on a slight grade.

Locations

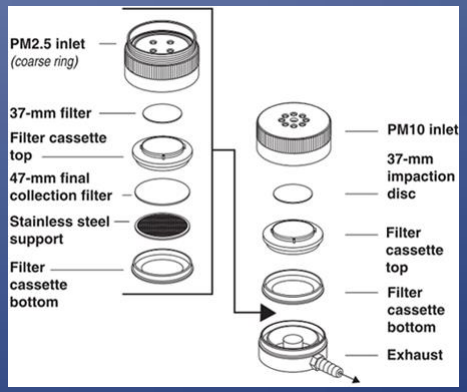
- Location continued:
  - Site #5, Camp Forsyth had co-located units and attempted to document the variability of these units. A paved parking area was adjacent to the site and a green space to the other side. The parking area was busy at times. Primary traffic flow was >100 meters away.

Map locations of the five sampling site on Fort Riley Kansas

SKC Deployable Particulate Sampler Systems (SKC Inc., Eighty Four, PA 15330)



- Course impact sampler (the PM 10 head is gold colored, pictured is the PM 2.5 head)
- 47 mm Whatman Quartz Filters, Grade QM-A (Whatman, Clifton, NJ).
- Filters conditioned to temperature and humidity prior to weighing pre and post sampling.



Sampling Periods

- Thirty two days (32 d) of air quality (AQ) sampling planned,
  - Two day background sampling period:
    - February 23 -24, 2012
  - Thirty day main sampling period:
    - March 15 – April 14, 2012
      - Exclusions occurred that subtracted three (3) days from this period
  - **Nineteen days, no sampling occurred:**
    - **February 25 – March 14, 2012,**

- Each morning, starting at approximately 8 am CST, data was collected, filters and batteries were replaced, and unit calibrations occurred over an 1.5 hour period. The sites were visited in the same order each day.

Daily Procedures

- Each day, the data was recorded on a Field Data Sheet (FDS).
- The data recorded at the start of each 24 hours:
  - The date, time of day, temperature (F), barometric pressure (mmHg), calibrated flow rate adjusted to 10 Lpm, and the assigned numbered filter.
- The data recorded at the end of each 24 hours:
  - Time of day, temperature (F), barometric pressure (mmHg), and flow rate as it is observed without adjustment on the flow calibration unit .

Field Data Sheet (FDS)

- The daily written data was entered into an electronic FDS. The electronic version had the formulas for calculating the PM10 measure for each unit.

  – Equation for calculating PM10 measurement:

PM Concentration ($\mu g/m^3$) = $(Wn)(10^3)/Va$ where:

Wn (µg) = Post Weight – Pre Weight

Va = Qact (Lpm) x Total Time (min)

Qact (Lpm) = Beginning Sampling Flow (Lpm) + End Sampling Flow (Lpm)/2

Days and Exclusions

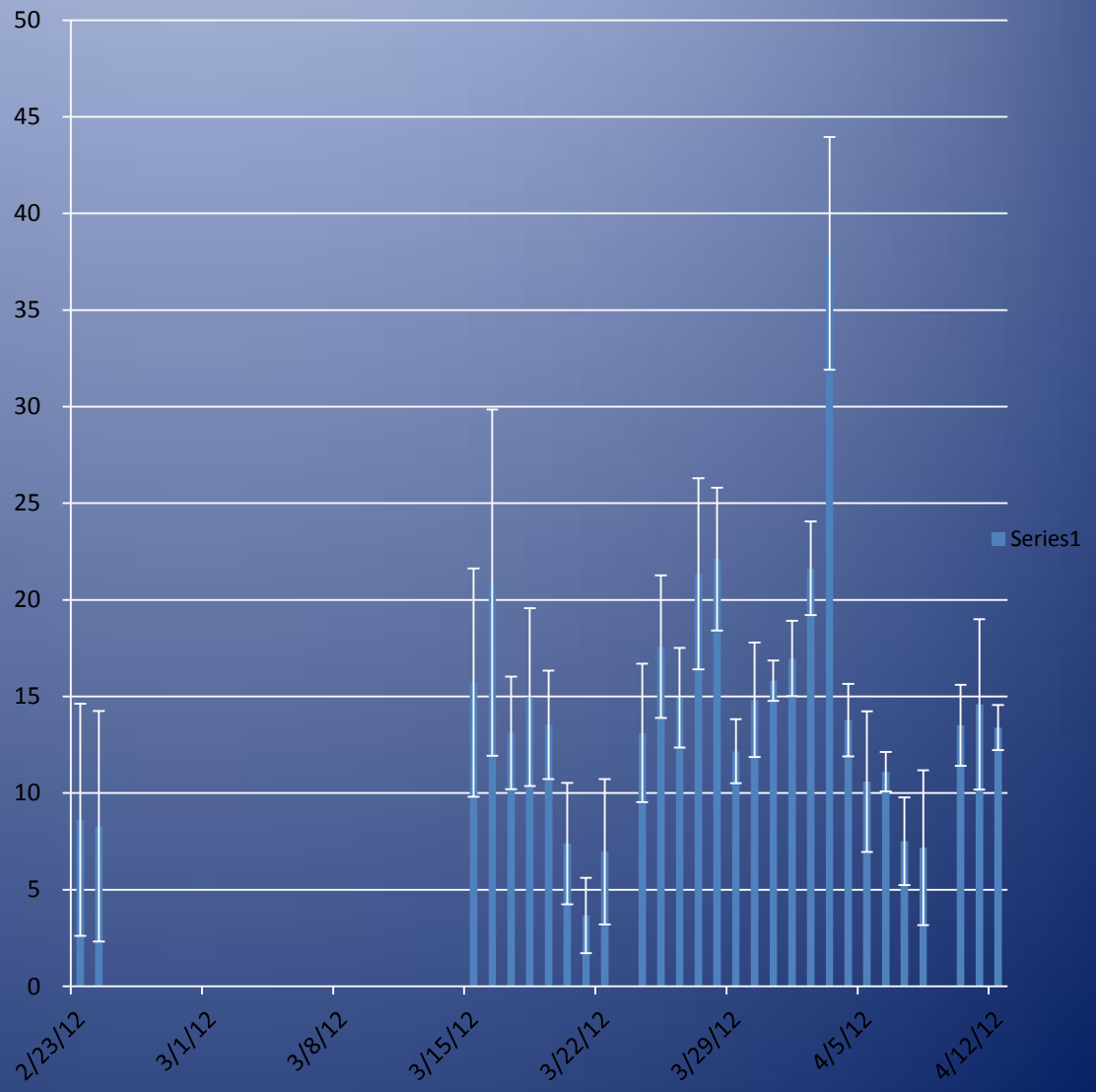
- 28 day main sampling period considered (30 days planned) Absent from data:
  - No sampling occurred on March 23 due to heavy rain
  - Units recovered April 13th at the end of 24 hour period (one day early)
  - Data exclusions:
    - Zero net filter weight, (3/22/2012, Unit #5)
    - No time/unit did not run, (4/1/2012, Unit #6)
    - Outliers beyond 10 standard deviations, (4/2/2012 Unit #5)
    - Negative net filter weight, (4/7/2012, Unit #3)
    - Filter weights with negative weight changes that affected an entire day of data, see (4/9/2012, 6 filters)

Basic Data

- Range of individual PM10: 1.93 – 44.05 µg/m³
- Mean of combined PM10: 14.04 µg/m³
- Best AQ day: March 21st, Mean 3.66 µg/m³
  - Cloudy, 55.4 F, 0.67” precipitation
- Worst AQ day: April 03rd, Mean 37.93 µg/m³
  - Clear, 64.5 F, 0.00” precipitation

Daily Means Across Locations

Date	Mean	STD
2/23/12	8.62	6.01
2/24/12	8.28	5.96
3/15/12	15.71	5.91
3/16/12	20.89	8.96
3/17/12	13.11	2.91
3/18/12	14.97	4.60
3/19/12	13.53	2.81
3/20/12	7.39	3.15
3/21/12	3.66	1.95
3/22/12	6.96	3.76
3/24/12	13.11	3.59
3/25/12	17.57	3.69
3/26/12	14.93	2.58
3/27/12	21.34	4.95
3/28/12	22.11	3.69
3/29/12	12.16	1.66
3/30/12	14.82	2.97
3/31/12	15.81	1.04
4/1/12	16.96	1.96
4/2/12	21.63	2.42
4/3/12	37.93	6.02
4/4/12	13.77	1.88
4/5/12	10.59	3.64
4/6/12	11.10	1.02
4/7/12	7.50	2.27
4/8/12	7.17	4.01
4/10/12	13.51	2.09
4/11/12	14.59	4.40
4/12/12	13.39	1.16

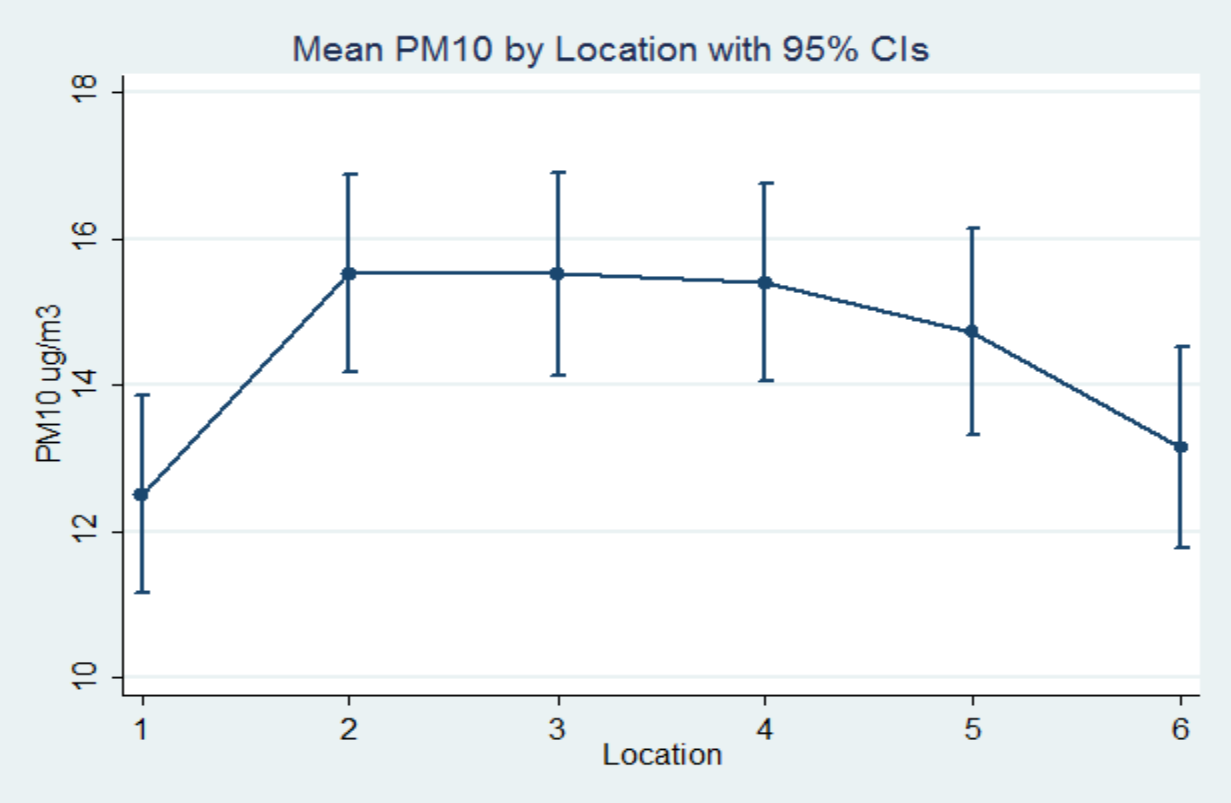


Means By Location

By location

- Mean of Site #1: **11.92** µg/m³, STD 6.35
- Mean of Site #2: **15.24** µg/m³, STD 6.37
- Mean of Site #3: **15.08** µg/m³, STD 8.01
- Mean of Site #4: **15.30** µg/m³, STD 7.58
- Mean of Each Unit at Site #5:
  - Unit #5: **14.37** µg/m³, STD 8.67
  - Unit #6: **12.32** µg/m³, STD 6.34

Model Adjusted Means by Location



Locations and Units are synonymous for #1 - #4. Location (Units) #5 and #6 are co-located at Site #5 but are analyzed individually. ANOVA analyses

Model Adjusted Mean by Location

Model Adjusted Mean, Standard Error, and p-value by Site Location						
Site	1	2	3	4	5	5
Unit[1]	1	2	3	4	5	6
Mean[2]	12.5	15.52	15.51	15.39	14.72	13.15
Standard error	0.69	0.69	0.7	0.68	0.71	0.7
Contrast 1 vs. all others[3]		**0.002**	**0.003**	**0.004**	**0.028**	0.51
Contrast 5 vs. all others[3]	**0.028**	0.427	0.435	0.502		0.12
Contrast 6 vs. all others[3]	0.51	**0.018**	**0.019**	**0.024**	0.12	

[1] **One unit was located at each of sites #1-4; two units were located at site #5**

[2] **ANOVA adjusted daily means for excluded data and is reflected as a Margin**

[3] **ANOVA analyses, units #5 and #6 analyzed as separate locations in this chart yet are co-located units**

Bold cells reflect statistical difference between specified unit and contrasted unit (P<0.05)

EPA Standards

- PM10 24 hour standard is 150 µg/m^3
  - It is not to be exceeded more than once each year on a three year average.
  - National Ambient Air Quality Standards (NAAQS) will be reviewed every five years and scheduled for 2013. No proposals pending to change this standard.
- PM2.5 24 hour standard is 35 µg/m^3
- PM2.5 annual standard is 15 µg/m^3
  - This standard is proposed to decrease to a value between 12 – 13 µg/m^3. The NAAQS will be reviewed in 2013.

Spring 2012

- The burning season was limited.
  - In the primary 14 county Flint Hills area, an estimated 285,715 acres were burned as compared to 1.2 million acres in 2009 or 1.3 million in 2005 (Doug Watson, KDHE Bureau of Air).
  - A warm winter, moderately low residue from 2011 and early growth affected the total number of acres and the pattern of burning.
  - West of K 177 HWY may have had less burning than east of the highway. (Subjective observation)
  - The burning season was nearly complete by the first week of April in 2012.

PM Monitoring on Fort Riley

- No PM10 values exceeded the EPA PM10 maximum of 150 µg/m³.
- Even with statistical differences among the sampling sites, the significant differences were of limited practical use for determining a PM sampling location.
- When determining a PM monitoring location, these considerations should be taken into account: the ease of access, the security of the unit, and the local environmental factors.

Types of PM Monitoring

- Twenty four hour continuous sampling utilizing high volume monitors and disc filters are not sensitive or practical enough to make daily decisions regarding health policies.
  - It is impractical to send filters to a laboratory for measurement when real time data is needed.
- Tapered Elemental Oscillating Microbalance Monitors (TEOM) are continuous monitors that provide real time data. Some monitors are capable of data output in seconds to minutes.

TEOM Monitors

- Kansas utilizes several of these monitors.
  - They may be fixed or mobile and the data remotely accessed.
  - The estimated cost for a mobile unit is $45,000 - $50,000. Personnel training, maintenance, and storage are additional costs to consider.
  - The KDHE Bureau of Air is a resource to approach when considering purchase vs. lease vs. collaborative agreements.

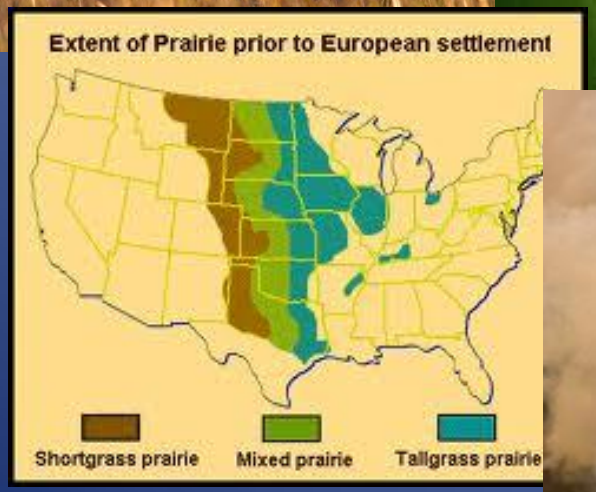
PM policy development on Fort Riley

- The Fort Riley Department of Public Health will have the lead role in PM monitoring if continued and furthering PM policy development. These policies, if developed, will augment regulations and policies that protect the Soldiers and civilian employees in the outdoor working environment.
- Policy considerations:
  - Age of Soldiers and personnel of concern
  - Health status of Soldiers and personnel of concern
  - The benefit/cost relationship of developing formal policies

Air Pollution and Human Health

- Points of consideration regarding PM and ozone.
  - Particulate matter acutely affects the cardiovascular system, and to a lesser degree, the respiratory system whereas ozone acutely affects the respiratory system. Together, they may enhances the affects of the other.
  - A 10 μg/m³ increase in PM2.5 increases RR of acute cardiovascular mortality (within hours to days of exposure) by 1%. Longer term exposures have more profound effects. This correlates to 1 additional death in 5 million persons. WHO correlates this to 800,000 – 1 Million deaths annually worldwide.
  - Independently or together, chronic exposures of each cause long term morbidity and mortality in susceptible individuals.
  - PM2.5 and UFPs are considered the primary concern. The direct effects of PM10 are more ambiguous.
  - Co-pollutants, i.e., oxides of Nitrogen and Sulfur, Lead, CO and VOCs are closely associated with some PM sources. Collectively, PM and co-pollutants affect human health.
  - Particulate matter is an ongoing concern because of its effects on human health, most notably—acute cardiovascular related deaths.

Questions?


Extent of Prairie prior to European settlement
Shortgrass prairie
Mixed prairie
Tallgrass prairie