Monitoring Air Toxic Particulate Pollutants from Heavily Trafficked New Jersey Turnpike
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Introduction

NJ turnpike connects New York and Philadelphia with more than 1/2 million cars per day.

Traffic emissions have lead to elevated concentration of HAPs near highways compared to the average urban background.

This study measured pollutant levels at different distances from the NJ turnpike, seasonal effects and traffic and weather effects on PAH’s, TSP and PM2.5 and associated metals.
Objective

• Measure ambient concentration gradients of $\text{PM}_{2.5}$, TSP, PAHs and their associated Trace Metals at different distances from the NJ Turnpike.

• Determine how particulate concentration from vehicle emission is affected by seasons, day/night, traffic flow variations and meteorological conditions.

• Design and test a visualization tool for interactively displaying spatial-temporal patterns of highway Air quality.
Experimental Design

- **Sampling Periods:**
  09/07-09/08 with EPA 6-day Monitoring Schedule

- **Sampling Duration:**
  - Long term: 24 hrs (12 months)
  - Intensive: 12 hrs (one week in each season)

- **Sampling Distances:**
  50, 100 and 150 m from TPK

Carlstadt, New Jersey Turnpike
Measured Variables

- PM$_{2.5}$, TSP and PAHs
  - Intensive sampling only

- Distance (m)
  - 50
  - 100
  - 150

- Season
  - Summer
  - Winter

- Diurnal
  - Day
  - Night

- Week
  - Weekday
  - Weekend

- Traffic

- Meteorological conditions
Sampling Sites: A, B, and C

A: 50 m
B: 100 m
C: 150 m

Turnpike
PM$_{2.5}$, TSP, 16 PAHs & 10 Trace Metals Sampling

PM$_{2.5}$ Sampler:
- Model: Partisol-FRM 2000
- Flow rate: 16.7 L/min
- Duration: 24 hours
- Media: PTFE Filter (47 mm ID)
- Compounds: PM$_{2.5}$ and Metals

Hi-vol. Sampler:
- Model: Tisch-PNY1123
- Flow rate: 0.5~0.7 m$^3$/min
- Duration: 24 hours
- Media: Quartz Fiber Filter and PUFs (3” height)
- Compounds: TSP, PAHs
MRS Model 100 has 8 cut off size: 0.18, 0.32, 0.56, 1.0, 1.8, 3.2, 5.6 and 10 um

Marple & Olson, KONA, 2009

MOUDI (Micro Orifice Uniform Deposit Impactor)
- Particle size distribution measurement
Distance effects

PM2.5, TSP and PAH
Distance effect PM2.5
24 hour average

PM2.5 (µg/m³)

Sampling Time (09/07-09/08)

Distance effect
PM2.5
24 hour average

Sampling Time (09/07-09/08)
Distance Effect on Three Metals in PM$_{2.5}$
Distance effect TSP
24 hour average

Sampling Date (09/07-09/08)
Distance effect on PAH
24 hour average

Sampling Time (09/07-09/08)
PAHs and TSP 24 hrs Average Ambient Air Concentration at Site A

TSP Guideline, 120 ug/m³ (WHO)
PM2.5 and PAH 24 hrs Average Ambient Air Concentration at Site A

PM2.5 EPA Guideline

PM2.5 and PAHs
Traffic effects
Total Traffic Count Effects on PAH, TSP and PM$_{2.5}$

$\Sigma_{16}$PAH = 0.0007 × Traffic - 31.91 ($r^2 = 0.19$, $p < 0.001$)

TSP = 0.0012 × Traffic - 58.26
($r^2 = 0.18$, $p < 0.001$)

PM$_{2.5}$ = 0.0001 × Traffic - 4.50
($r^2 = 0.02$, $p > 0.05$)
Gasoline and Diesel Traffic Counts Effects on Total PAHs

\[ \Sigma_{16} \text{PAH} = 0.0005 \times \text{gasoline} + 14.05 \quad (r^2 = 0.09, \quad p < 0.05) \]

\[ \Sigma_{16} \text{PAH} = 0.001 \times \text{diesel} + 13.24 \quad (r^2 = 0.14, \quad p < 0.05) \]
Gas and Particle Partitioning of 16 PAHs

**Gas Phase**

**Particulate Phase**

PAH (ng/m$^3$)
\[ \sum \text{PAH concentration at Various Locations in the East Coast} \]

**Phenanthrene**

**Pyrene**


Meteorological effects
PAHs vs Temperature, Wind speed (Site A)

\[ \Sigma 16\text{PAHs} = 0.839 \times \text{Temperature} + 18.25 \]
\( (r^2=0.20, \ p<0.05) \)

\[ \Sigma 16\text{PAHs} = -0.832 \times \text{Wind speed} + 34.7 \]
\( (r^2=0.11, \ p<0.05) \)
Seasonal effects
Seasonal and Distance Effect on TSP and PAHs

TSP

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PAHs

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TSP concentration, µg/m³

Total PAHs (Gas+Particle), ng/m³
Seasonal and Distance Effect on PM$_{2.5}$

![Box plot showing PM$_{2.5}$ concentrations for different seasons and distances.](image-url)
Seasonal Effect on Metals

Seven of ten behave like Fe, Al

Ni and Zn behave opposite
Day of the week
Effect of Day-of-Week on TSP and PAHs

**TSP**

**PAHs**

TSP concentration, µg/m³

Total PAHs (Gas+Particulate) concentration, ng/m³
Metal concentrations associated with particle size
Types of Trace Metal Size Distribution From Turnpike, NJ

- **Type I-Ni, V**
  - PM Size, Dp(μm)
  - dC/dlog(Dp)(ng/m³)
  - Graph showing distribution of Ni and V with PM size.

- **Copper**
  - PM Size, Dp(μm)
  - dC/dlog(Dp)(ng/m³)
  - Graph showing copper distribution with PM size.

- **Type II-Pb, Cd, Zn**
  - PM Size, Dp(μm)
  - dC/dlog(Dp)(ng/m³)
  - Graph showing distribution of Pb, Cd, and Zn with PM size.

- **Type III-Fe, Al, Cr and Sc**
  - PM Size, Dp(μm)
  - dC/dlog(Dp)(ng/m³)
  - Graph showing distribution of Fe, Al, Cr, and Sc with PM size.
Distribution of Individual Metals According to Size Fraction

% of Total Concentration

- Fe
- Sc
- Al
- Cr
- Cu
- Zn
- Pb
- Cd
- Ni
- V

< 2.5 μm
> 2.5 μm
Conclusions

• Near roadway emissions did not significantly affect the concentration of PM$_{2.5}$ mass
• There were no significant differences in seasonal PM$_{2.5}$ concentration ($p > 0.05$).
• The concentrations of TSP and PAHs at 50 m were higher than at 100 and 150 m.
• The higher TSP concentration was observed in the spring and summer compared to the fall and the winter ($p < 0.05$).
Conclusions (continued)

• Total PAHs concentrations were higher in the summer compared to winter at site A (p <0.05).
• There was no distance gradient of trace metals associated with PM$_{2.5}$.
• Of the 10 metals, 7 were higher in the summer than winter, Ni and Zn were higher in the winter than summer.
• The distribution of metal concentrations associated with particle sizes followed 4 distinct patterns.
MERI Webpage

http://meri.njmeadowlands.gov/
Current_Projects/