Mapping Transportation-Related Air Pollution Along the Schuylkill River Trail

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Abstract

Fine Particulate Matter ($PM_{2.5}$) is an air pollutant characteristic of vehicle tailpipe emissions which negatively impacts outdoor air quality in urban areas. While Philadelphia monitors $PM_{2.5}$ pollution on the county level, gaps in the city's monitoring network limit access to targeted air quality information along popular mixed-use trails such as the Schuylkill River Trail (SRT) and the Martin Luther King Jr. Dr. (MLK) Trail. **This study investigated the impact of transportation-related air pollution (TRAP) on $PM_{2.5}$ concentrations experienced by users of the SRT and MLK Trail.** $PM_{2.5}$ TRAP concentration ratios relative to the regional background were derived from in-situ $PM_{2.5}$ data collected over 12 days between Feb 11th, 2024 and March 5th, 2024 as well as hourly background $PM_{2.5}$ data from the Montgomery Drive Air Monitoring Station. $PM_{2.5}$ TRAP hotspots were most frequent along Kelly Dr. and were at locations where high rates of traffic congestion on average and during rush hour periods existed. Schuylkill River Trail users should avoid these regions during periods of high traffic to limit excess exposure to $PM_{2.5}$. This thesis hopes to encourage further study into potential influences of transportation emissions on similar trails and bike infrastructure networks across Philadelphia.

Figure 1: Promontory Rock Tunnel ca. 1905 (top, Detroit Publishing Co.) and in 2024 (bottom) alongside the SRT and Kelly Dr.

Intro & Background

- The Schuylkill River Trail (SRT) is one of the most popular mixed-use trails in Philadelphia.
- Kelly Dr. and I-76 experience frequent traffic congestion.
- $PM_{2.5}$ exposure impacts cardiovascular, respiratory, and immune system fitness (Anenberg et al., 2019, Achakulwisut et al., 2019).
- Health benefits gained from outdoor exercise can be lowered or counteracted by excess $PM_{2.5}$ exposure (Chandia-Poblete et al., 2022).
- The proximity of the SRT to Kelly Dr. also carries risks of non-exhaust pollutants (NEPs) from brake and tire wear impacting trail users.

River Trail Pedestrian & Bike Counts (Jan - Mar 2024)

	Schuylkill	Delaware
🚶	46,373	38,797
🚲	41,614	27,179

Figure 2: SRT and DRT bike & pedestrian counts Jan - Mar 2024 (DVRPC, 2024).

Methods

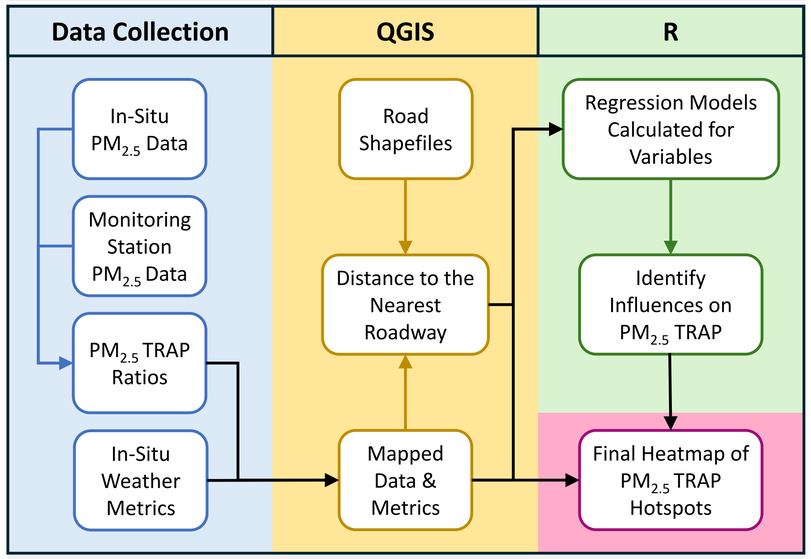

Figure 3: Flowchart of Methods progression, categorized by stage of analysis

$$PM_{2.5}\ TRAP\ Ratio = \frac{Measured - Background}{Background}$$

- In-situ $PM_{2.5}$ data were collected over 12 periods between 2/11/2024 to 3/5/2024.
- Large outliers from 2/23 were identified through quantile and IQR analyses & omitted from heatmap creation.
- A Kernel Density analysis (Shi et al., 2019) was performed in QGIS with $PM_{2.5}$ TRAP Ratios as the weight factor to generate a final heatmap (**Figure 6**).

Figure 4: Instrument setup used for data collection over the course of four weeks.

Results

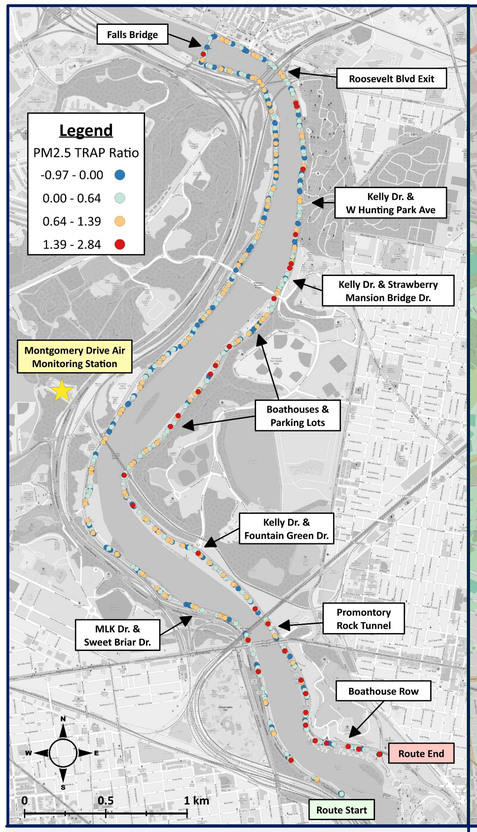

Figure 5: $PM_{2.5}$ TRAP data points & landmarks.

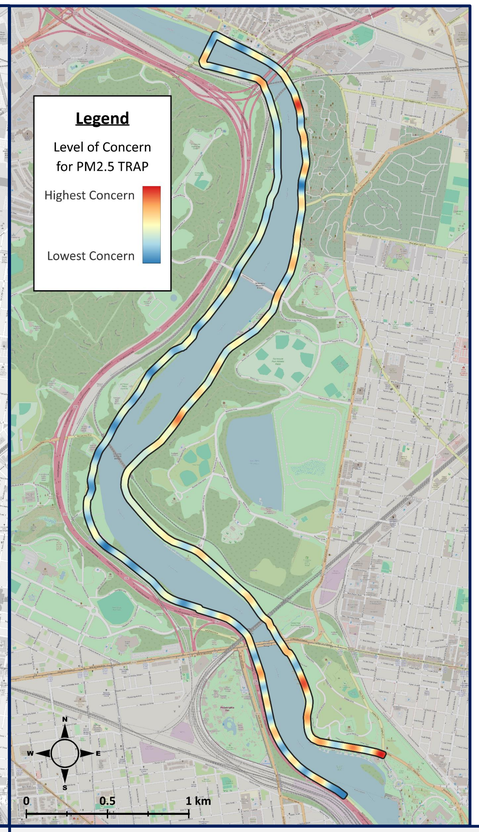

Figure 6: $PM_{2.5}$ TRAP regions of concern heatmap from kernel density analysis.

- When omitting outliers, $PM_{2.5}$ TRAP Ratios ranged from **97% below** to **284% above** the background.
- Notable regions of high $PM_{2.5}$ TRAP include:
  - Boathouse Row
  - Roosevelt Blvd. Exit
  - MLK Dr. from Route Start until Sweet Briar Dr.
- The SRT experiences higher levels of $PM_{2.5}$ TRAP on average than MLK Dr.
- Linear Regressions of meteorological metrics with $PM_{2.5}$ TRAP ratios yielded **statistically significant but weak relationships with low adjusted R^2 values.**

Discussion

- Regions of high $PM_{2.5}$ TRAP are located where nearby traffic congestion was higher and closer to the trail on average than other regions of the trail network.
- Low values from the Montgomery Drive Air Monitoring Station on 2/23 relative to the mean of measured $PM_{2.5}$ concentrations produced higher-than-average $PM_{2.5}$ TRAP ratios. Regional air quality was poor during the 2/23 collection period (AQI = 66), but not abnormally so.
- The level of $PM_{2.5}$ above the background was assumed to have been entirely attributable to motor vehicle sources and therefore a measure of TRAP, but other factors not measured in this study impacting $PM_{2.5}$ likely existed.

Study Limitations

- One month collection timeframe
- Availability of background concentration data
- Instrument reliability issues
- Long-term applicability concerns

Conclusions

- **Users of the Schuylkill River Trail should avoid areas close to Boathouse Row and the Roosevelt Blvd. Exit during periods of high traffic congestion.**
- Partial mitigation of TRAP using vegetation barriers between the SRT and Kelly Dr. is possible (MacNaughton et al., 2014) but not a complete solution. Reductions in vehicle traffic on Kelly Dr. would bring the greatest benefits.
- Further research on TRAP must be conducted on the SRT and other trail networks across Philadelphia.

References

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