ANALYSIS OF AMBIENT AND EMISSION MONITORING TO IDENTIFY LOCAL AIRSHED IMPACTS

Matthew Adams, Ph.D.

Presentation to Region of Durham Works Committee

Introduction

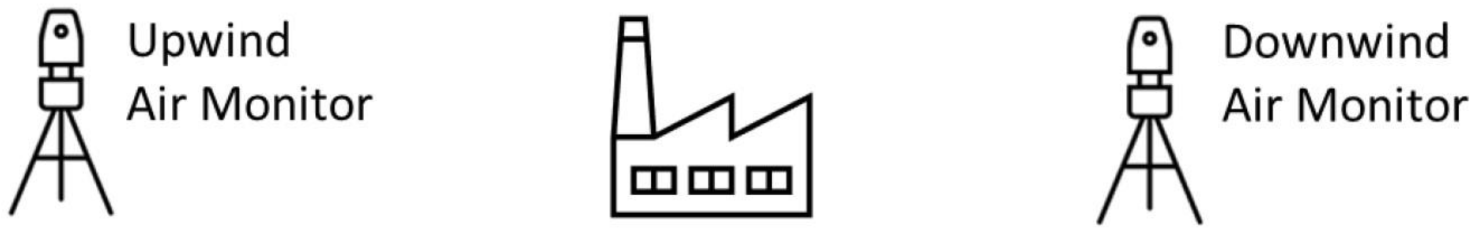
- Professor in the Department of Geography, Geomatics and Environment at the University of Toronto
- Director of the Centre of Urban Environments at the University of Toronto
- Research program examines urban air pollution exposure and the underlying processes
- Independent study of DYEC data

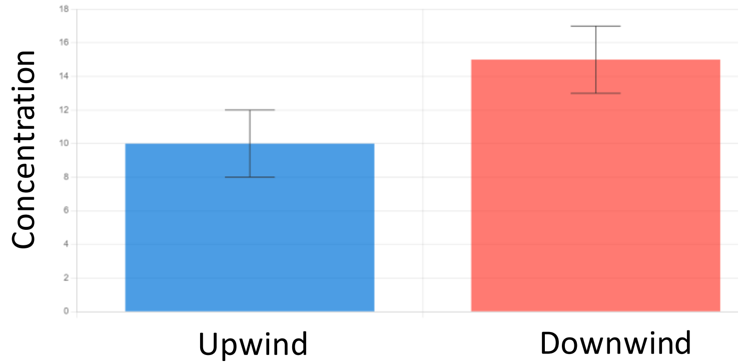
Time-series analysis of the Continuous Emission Monitoring (CEM) and Ambient Air Monitoring Stations

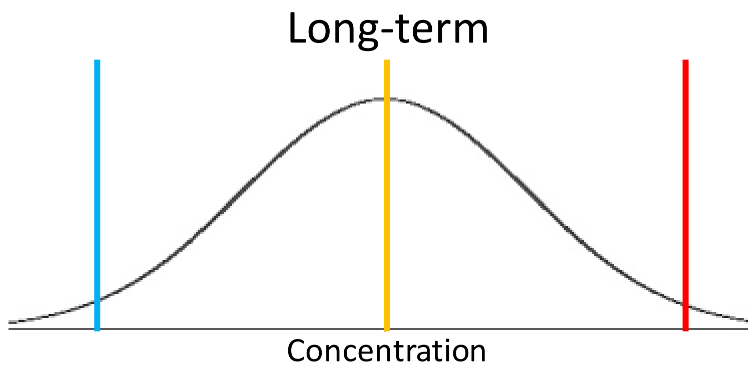
Objective

Identify if the Durham York Energy Centre’s (DYEC) emissions have a significant impact on ambient air while ensuring local meteorological or background air pollution concentrations are not skewing the findings.

Approach

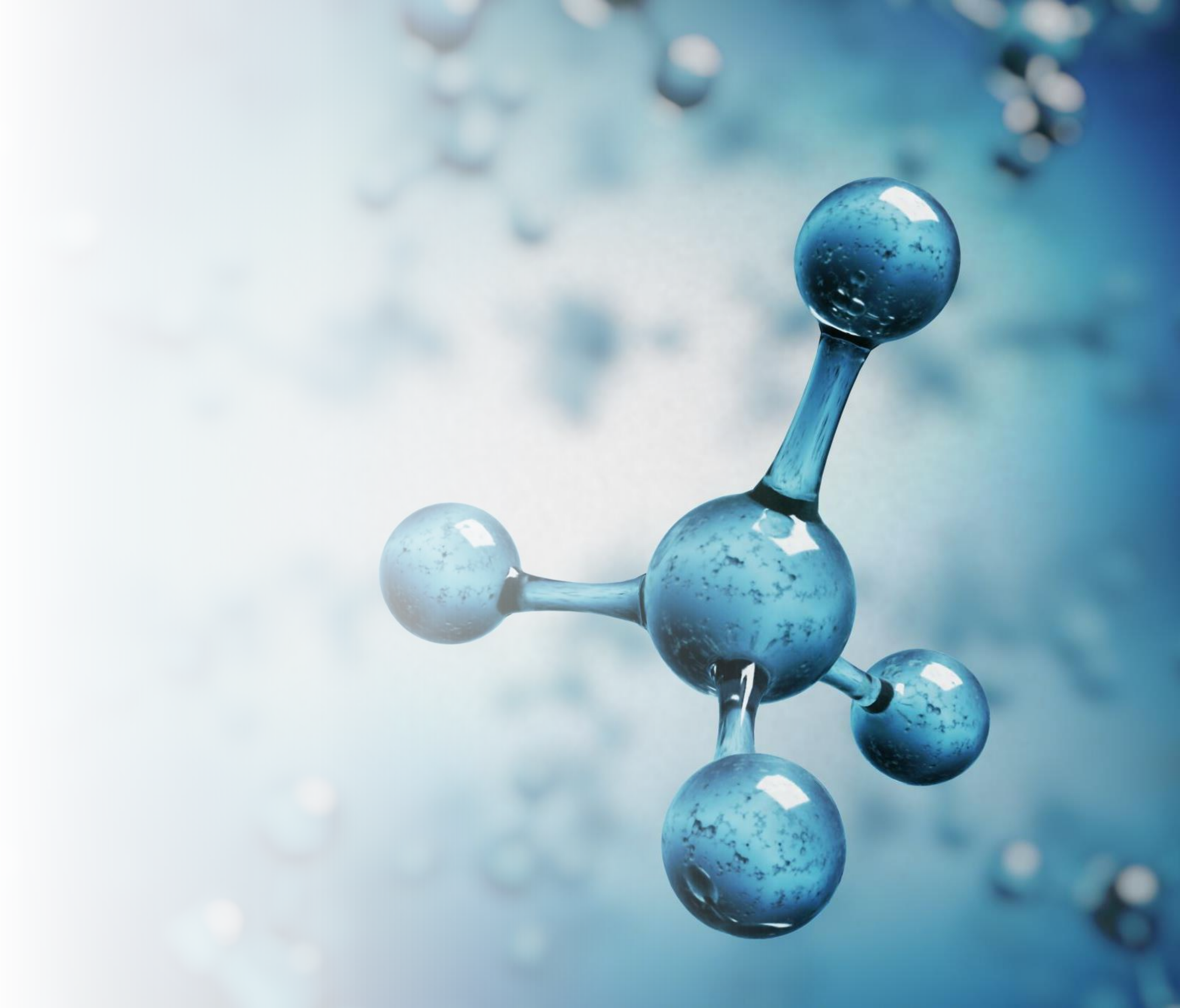

Upwind
Air Monitor
Downwind
Air Monitor


Concentration
Upwind
Downwind


Long-term
Concentration

Pollutants Examined

- Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF)
    - Dioxins and Furans
- Polycyclic aromatic hydrocarbons (PAHs)
- Total suspended particulate (TSP) including the concentrations of metals.
- Nitrogen oxides (NO_X)
- Sulphur dioxide (SO_2)
- Particulate matter 2.5 microns or smaller in aerodynamic diameter ($PM_{2.5}$)



Analysis Approaches

1. Discrete Monitoring (PCDD/PCDF, PAH & TSP)
2. Ambient air monitoring analysis with continuous emissions monitoring (NO_X & SO_2)
3. Ambient air monitoring analysis without continuous emissions monitoring ($PM_{2.5}$)

Discrete Monitoring

Hypothesis

If air pollution emissions from the DYEC affect the local air, downwind concentrations will be statistically significantly higher than the upwind concentrations due to the additional pollution.

However, if higher concentrations occurred during non-downwind conditions, it would suggest potential local sources other than the DYEC.

- Each observation was assigned to Rundle Downwind, Courtice Downwind or Crosswind conditions (45° window for both downwind conditions)
- Concentration data during each period were compared using a statistical analysis to determine if any significant difference occurred between the values

Discrete Monitoring Results

- Data: TSP (330 days), PAHs (173 days) and dioxins and furans (94 days)
- No pollutants were significantly higher when the Courtice monitor was downwind
- 18 pollutants significantly higher when Rundle Road was downwind, however:
  - 10 of those were also significantly higher during cross-wind conditions
  - Remaining eight were higher (not significant) during cross-wind conditions

Discrete Monitoring Dioxins and Furans Interpretation

- Mean toxic equivalency (TEQ) per m^3 for all samples is below MECP Ambient Air Quality Criteria (0.1 pg TEQ/m^3)
  - Rundle Road (0.0157 pg TEQ/m^3)
  - Courtice (0.0127 pg TEQ/m^3)
- National Pollutant Release Inventory indicates DYEC emits a small portion within the region
  - 2.2% of total emissions between 2015 and 2021
- The analysis in this report does not suggest that DYEC emissions impact local concentrations of dioxins and furans

Dioxins and Furans Comparisons

DYEC's annual emissions are emitted by Canada's largest emitter in less than one day.

The DYEC emits 0.63% of dioxins and furans compared to Canada's forest fires each year.

Discrete Monitoring PAH Interpretation

- Nine compounds higher (Rundle Downwind); however, all of those were higher during crosswind conditions.
- Concentrations generally much below criteria:
  - 1-Methylnaphthalene 12,000 ng/m^3 (Courtice: 5.5 ng/m^3; Rundle: 8.5 ng/m^3)
  - 2-Methylnaphthalene 10,000 ng/m^3 (Courtice: 9.7 ng/m^3; Rundle: 15.9 ng/m^3)
  - Acenaphthylene 3,500 ng/m^3 (Courtice: 0.2 ng/m^3; Rundle: 0.3 ng/m^3)
  - Anthracene 200 ng/m^3 (Courtice: 0.2 ng/m^3; Rundle: 0.5 ng/m^3)
  - Naphthalene 22,500 ng/m^3 (Courtice: 24 ng/m^3; Rundle: 28 ng/m^3).
  - Benzo(a)pyrene AAQC - 0.05 ng/m^3 (Courtice: 0.03 ng/m^3; Rundle: 0.04 ng/m^3)
    - O. Reg. 419/05 Schedule Upper Risk Thresholds: 5 ng/m3

Discrete Monitoring PAH Interpretation (BaP)

- Benzo(a)pyrene was not statistically significantly higher at the downwind air monitor compared to upwind concentrations
- Concentrations were consistently higher at the Rundle Road air monitor regardless of the wind direction
- The smallest increase in concentrations between Rundle Road and Courtice occurred when Rundle Road was downwind
  - If the DYEC was responsible, that is when the highest increase should have occurred.

Discrete Monitoring TSP Interpretation

- Average concentrations measured at both the Courtice (25 μg/m^3) and Rundle Road (32 μg/m^3) are below annual AAQC (60 μg/m^3)
- A few components of TSP were higher when Rundle was downwind; however, all of those were higher or significantly higher during cross-wind conditions.
- DYEC reports manganese emissions to Canada's National Pollutant Release Inventory; within Durham and York regions, the DYEC emitted <0.001% of emissions between 2015 and 2021.
- No evidence that TSP ambient concentrations are impacted by the DYEC

Metals General Comparison

- In one day, brake wear from passenger vehicles emit more Zinc, Manganese, and Copper along the 401 than the DYEC does in a year.
  - Arsenic equivalent emissions is reached in 39 days.
  - Lead in 50 days.

Ambient air monitoring analysis with continuous emissions monitoring (NO_X & SO_2)

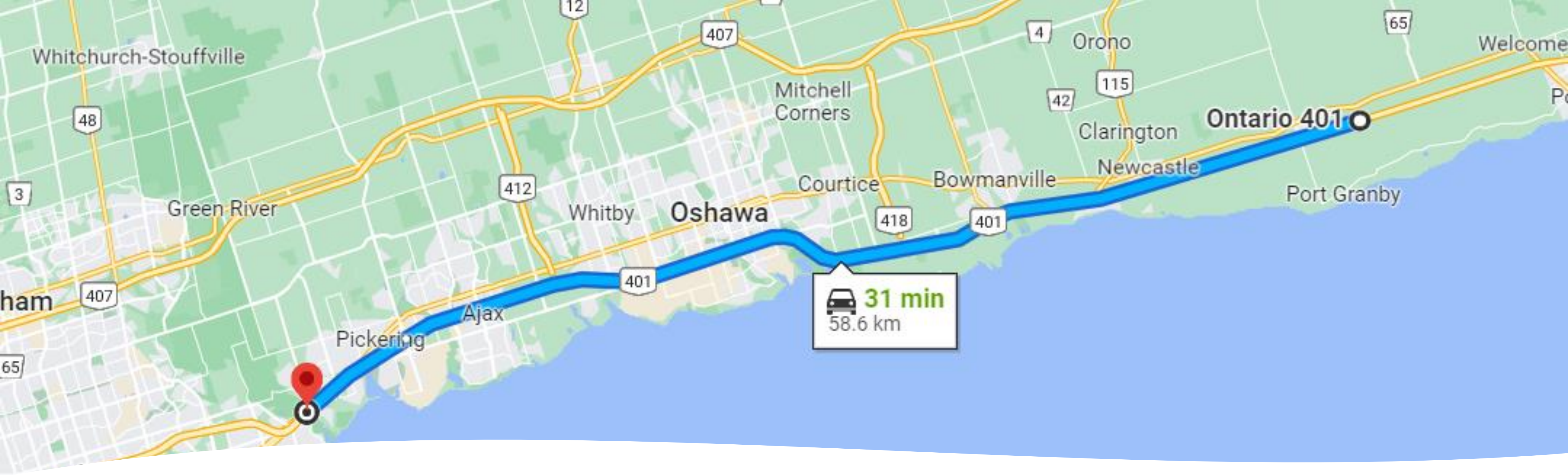
- Hypothesis: if air pollution emissions from the DYEC affect the local air, measured emissions will explain the differences in downwind concentrations.
- The difference in downwind and upwind concentrations should be related to changes in emissions.
- A linear regression model was applied where the emissions were regressed against the difference in concentrations (Rundle Road Downwind Conditions).

NO_X & SO_2 Results

- Rundle Road downwind conditions for NO_X were 7.5 ppb at Rundle Road and 7.1 ppb at the Courtice monitor
  - NO_2 AAQC (100 ppb)
  - Statistical model demonstrated no relationship between emissions and downwind increases

- Rundle Road downwind conditions demonstrated higher concentrations at the Courtice monitor (1.80 ppb) compared to the downwind Rundle Road monitor (0.65 ppb)
  - Annual AAQC (4 ppb)
  - Statistical model demonstrated no relationship between emissions and downwind increases

- Neither pollutant demonstrated any impact by the DYEC
  - A local SO_2 source likely occurs impacting the Courtice monitor



NO_X General Comparison

Annual emissions of the DYEC is equivalent to 15 days of vehicle emissions along the 401 in Durham Region.

Ambient Monitoring ($PM_{2.5}$)

- $PM_{2.5}$ data were separated by wind direction (Rundle Downwind, Courtice Downwind & Crosswind)
- A statistical test was applied to determine if the measured concentrations during those conditions were statistically significantly different ($p < 0.05$) between the Courtice and Rundle Road concentrations.

$PM_{2.5}$ Results

No difference observed during any wind condition

Mean Concentration (μg/m³)					
Wind Condition	Courtice	Rundle Road	t	df	p
Rundle Downwind	8.0	8.0	-0.18	1005	0.86
Courtice Downwind	6.6	7.0	-0.77	330	0.44
Crosswind	5.8	5.9	-0.09	3165	0.93

NPRI EMISSIONS (Durham and York)

2015 to 2021

	Emissions			
Pollutant	Units	DYEC	Regional	DYEC Contribution (%)
Ammonia	tonnes	39.187	3777.381	**1.037**
Arsenic	kg	0.27	42.43	**0.64**
Cadmium	kg	0.67	195.83	**0.34**
Cobalt	kg	0.43	31.83	**1.35**
Copper	tonnes	0.0131	0.9686	**1.35**
Dioxins and furans - Total	g TEQ	0.1904	8.8316	**2.16**
Hexachlorobenzene	grams	Zero	3451.24	**Zero**
Lead	kg	2.96	3558.90	**0.08**
Manganese	tonnes	0.0095	115.0316	**0.0082**
Mercury	kg	2.24	1192.57	**0.19**
Nitrogen oxides	tonnes	975.70	27346.03	**3.57**
Phosphorus	tonnes	Zero	0.57	**Zero**
PM_{10}	tonnes	2.0990	3644.5190	**0.058**
$PM_{2.5}$	tonnes	1.5960	1530.6871	**0.104**
Zinc	tonnes	0.0311	54.6885	**0.057**

Conclusion

After conducting my analysis, none of the pollutants analyzed indicate any notable contribution from the DYEC to ambient air pollution concentrations.