

**University of Toronto**

**CHM 410**

**Lab 4**

**Toronto District School Board Air Quality: An Analysis of Carbon dioxide, Ozone, and  
Polycyclic Aromatic Hydrocarbons Outdoors and In-car During Drop Off Time.**

Group C

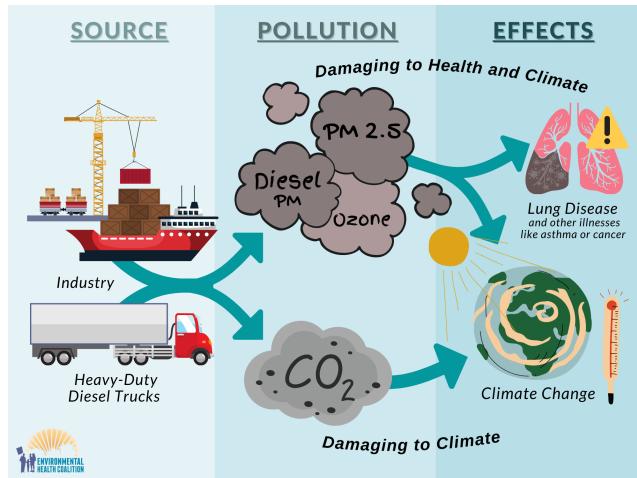
Submitted on December 8, 2023

## **Abstract**

This study evaluates air quality during children's morning school commutes with emphasis on the comparison between in-car and outdoor environments. Conducted from October 30th to November 23<sup>rd</sup>, 2023 at TDSB Secord Elementary School, the levels of carbon dioxide ( $\text{CO}_2$ ), particulate matter ( $\text{PM}_{2.5}$ ), ozone ( $\text{O}_3$ ), and polycyclic aromatic hydrocarbons (PAHs) were monitored during peak hours. It was found that there was no statistically significant difference in air quality between weekdays and weekends. However,  $\text{CO}_2$  levels were marginally higher on weekdays. Among PAHs, only naphthalene had concentrations above the limit-of-detection, with in-car ( $1.51 \times 10^{-6} \pm 7.10 \times 10^{-7} \text{ mg/m}^3$ ) being higher than outdoor ( $7.99 \times 10^{-7} \pm 7.55 \times 10^{-7} \text{ mg/m}^3$ ). This challenges the notion that cars provide safer air quality, highlighting concerns about vehicle self-pollution. The findings suggest walking to school as a healthier alternative, potentially reducing exposure to pollutants and benefiting overall community air quality.

## Client Deliverable

**Walking to school is more than just a means of transportation— it is a step towards a healthier future for our children and our community**



School neighborhoods face air quality concerns attributed to vehicle emissions. In an attempt to find out the air quality outside or in the car perceived by children during their commute, a group of students from the University of Toronto have conducted an air quality assessment around Secord Elementary School for a period of four weeks. The results suggested that the outdoor ozone, fine particulate matter (2.5  $\mu\text{m}$ ), and carbon dioxide levels were not significantly worse during the drop-off hours compared to weekends without any car traffic outside the school. In addition, naphthalene, a possible carcinogenic compound, was higher in the air inside the car than outside. The increased traffic during drop-off hours caused elevated levels of naphthalene on weekdays compared to weekends. However, all the observed levels of naphthalene were well below standards for safety concerns, and are not a cause for alarm. Choosing to walk or bike to school not only prioritizes the well-being of the children but will also contribute to creating a cleaner, more vibrant neighborhood. Lace up those sneakers, grab your child's / children's hands, and take a collective stride towards a healthier, happier future!

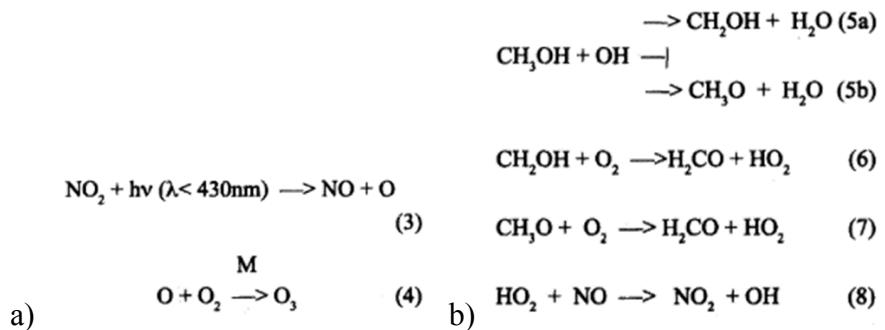
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## **1. Introduction**

Long-term exposure of ground-level tropospheric ozone ( $O_3$ ), carbon dioxide ( $CO_2$ ), particulate matter 2.5 ( $PM_{2.5}$ ), and polycyclic aromatic compounds (PAHs) have been shown to pose significant threat to human health by triggering respiratory disease such as asthma, pulmonary diseases and lung cancer (Witsch 1988; Standing et al., 2022; Thankgavel 2022). These consequences present additional risks to children as their respiratory systems are still developing which increases their likelihood of developing an illness and the potential for long term adverse health effects.  $O_3$  and  $PM_{2.5}$  are both crucial indicators of air quality and are being closely and continuously monitored to assess environmental conditions and public health risks by government and environmental agencies worldwide. Canadian standards are 63 ppb per rolling 8h average for  $O_3$  and 28 ug/m<sup>3</sup> per 24h average for  $PM_{2.5}$  as of 2020 (Canada's Ambient Air Quality, 2019).

In a vehicle's engine, fuel undergoes incomplete combustion, producing carbon monoxide (CO),  $CO_2$ , nitrous oxide ( $N_2O$ ), nitrogen oxides ( $NO_x$ ) and numerous other byproducts, including PM2.5 and volatile organic compounds (VOCs) which includes PAHs (Abi-Esber & El-Fadel, 2013).

$O_3$  is formed from precursors  $NO_2$  and VOCs and requires sunlight. The kinetics of the reaction are impacted by temperature which leads to a diurnal pattern of increasing  $O_3$  during the day and decreasing at night (Archibald et al., 2020). Figure 1 outlines the process of  $O_3$  generation from methanol as an example VOC (a) and from  $NO_2$  directly (b). Note in equation 3 the step requires light.



**Figure 1.** Tropospheric  $O_3$  generation from  $NO_2$  (a) and oxidation of organics (b). The production of  $HO_2$  and  $NO_2$  during the oxidation process contributes to formation of  $O_3$ . M represents a third body. Equations from Finlayson-Pitts & Pitts (1993).

$\text{CO}_2$  constitutes 0.04% of air and can reach higher levels in urban areas, mainly from car emissions. Although the impact of  $\text{CO}_2$  on human health is negligible,  $\text{CO}_2$  concentrations can serve as an indicator for increased traffic and limited air flow in the study site (*Carbon Dioxide 101.* (n.d.).

$\text{PM}_{2.5}$  refers to fine particles in air that have a diameter of less than 2.5 micrometers. These microscopic particles are released directly or formed in the atmosphere as a result of combustion processes, industrial activities, and vehicle emissions (Thangavel,2022).

Previous studies have shown PAH concentrations to be higher inside cars compared to the surrounding outside air, suggesting that vehicle-self pollution is likely responsible (Abi-Esber & El-Fadel, 2013). The term “vehicle-self pollution” refers to the emission of pollutants produced by the vehicle that subsequently enter and affect the air quality within the car itself.

The purpose of this study was to compare air quality during peak school drop-off times on weekdays and weekends at TDSB Secord Elementary School in the outdoors and in-car environments. Comparison is essential for evaluating the TDSB's initiative which is to encourage children to walk to school as opposed to driving. It was hypothesized that concentrations of O<sub>3</sub>,

$\text{CO}_2$ , and  $\text{PM}_{2.5}$  will be higher on weekdays due to increased vehicle activity. Additionally, polycyclic aromatic hydrocarbons (PAHs) concentrations are expected to be smaller in the outdoor environment compared to in-car, with elevated values during weekdays.

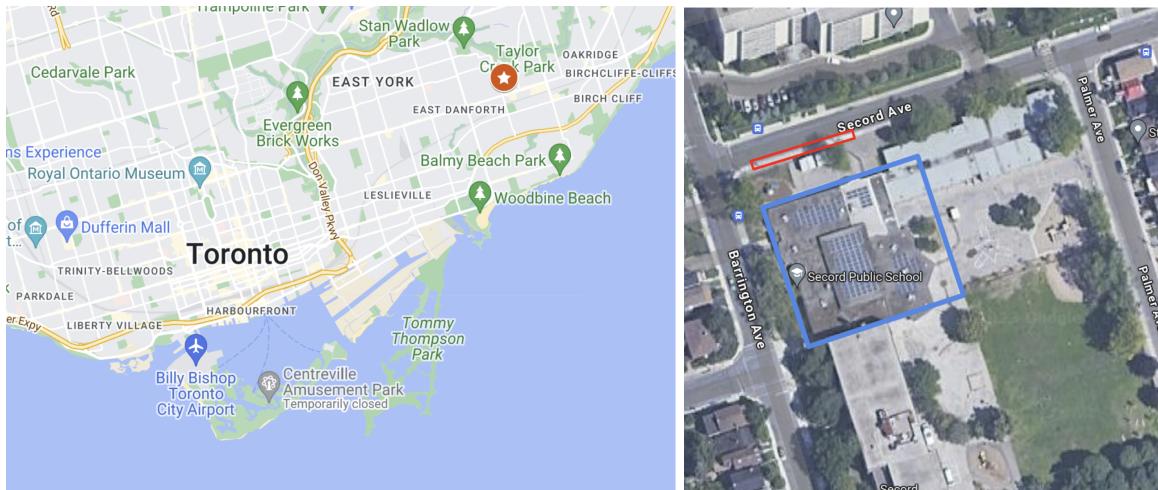
## 2. Materials and Methods

### 2.1. Target pollutants

$\text{O}_3$ ,  $\text{PM}_{2.5}$ ,  $\text{CO}_2$ , and five PAHs were sampled in this study.  $\text{O}_3$ ,  $\text{CO}_2$ , and  $\text{PM}_{2.5}$  concentrations were measured using Aeroqual air quality monitors outdoors on weekdays and weekends. For the measurement of PAHs, XAD cartridges connected to an air pump were used, operating concurrently with vehicle sampling to reflect the exposure during the same time frame.

### 2.2. Sampling time and location

The study was conducted over a period of six days, from October 30th to November 23rd, 2023, at Secord Elementary School, a member of the Toronto District School Board, located at 101 Barrington Ave. Exact location is shown in Figure 2. Measurements were taken during peak drop-off times, specifically between 8:30-10:00 am, to capture the typical morning commute conditions on both weekdays and weekends. The vehicle used for the sampling was a 2018 1.6T Hyundai Kona. It was driven around the neighborhood at speeds ranging from 10 to 20 km/h for a duration of one hour to simulate the typical driving conditions during school drop-off. Samples were collected from two locations: (1) In-vehicle samples were collected from the backseat, and (2) outdoor samples were collected at the rear entrance (drop-off point) of the school (Figure 1).



**Figure 1.** Sampling site marked in Toronto in a red star on left. School and specific sampling location near the road outlined in blue and red box respectively in the right image. © Google Maps 2023.

### 2.3. Instrumental details

$O_3$  and  $CO_2$  were measured using Aeroqual Series 500 handheld monitors (see SI Figure S1). Measurements were made at 1 minute intervals at height of around 1 - 1.5 m to reflect average height of children and ensure no horizontal gradient effects were impacting measurements. Data was logged onto the instruments and exported using the Aeroqual software. Measurements were made in 1 second intervals and recorded using their AirCasting software. The  $O_3$  monitor has a long warm-up time and was turned on 30 minutes beforehand to ensure consistent detection in air samples. This was not done on October 30<sup>th</sup>, November 4<sup>th</sup>, November 15<sup>th</sup>, and November 18<sup>th</sup>.

$PM_{2.5}$  was measured using HabitatMap's AirBeam, equipped with a Plantower PMS7003 optical particle counter that can measure  $PM_{2.5}$  concentrations up to 1000  $\mu g/m^3$ . The instrument uses a light scattering method. It first emits a laser beam into the air sample which will be scattered when fine particles pass through the beam. A photodetector is installed to capture the

light scattered by the particles at different angles and the amount of scattered light is proportional to the number and size of particles in the air.

PAH were sampled using an air pump and sorption onto XAD cartridges. Two XAD cartridges were connected in series to an air pump with a flow rate of average 1.00 L/min and pumped for 1 hour. The air pumps are shown in Figure S1 in the Supporting Information. The collected samples were sealed and stored in room temperature for one week to be eluted and analyzed in the laboratory. For analysis, XAD cartridges were eluted using 2 mL of ethyl acetate 99% (Merck, USA) in the laboratory and were analyzed using GC-MS (Thermo ISQ-7000) with EI ionization. GC nominal temperature was 300.0°C with injection volume of 2.0 µl, and flow rate of 1.000 mL /min. The GC column temperature ramp started at 50.0°C to 200.0°C for 18.75 minutes and then increased 200.0°C - 300.0°C for the next 10.00 minutes followed by 1.25 minute cooldown for a total of 30.00 minutes.

#### 2.4. Quality Assurance/Quality Control (QA/QC)

Background measurements of O<sub>3</sub>, CO<sub>2</sub>, PM<sub>2.5</sub>, and PAH were collected on weekends. Samples were systematically monitored and collected across seven different weekdays to ensure the robustness of the data through replicates. In addition to the automatic synchronization of O<sub>3</sub>, CO<sub>2</sub>, and PM<sub>2.5</sub> data, manual measurements were taken to avoid potential data loss. For each sampling day, one XAD cartridge was placed outside and another inside the car, both exposed to field conditions throughout the sampling period. Field blank concentrations were subtracted from sample concentrations using R to account for the outdoor and in-car environment for each distinct day. There were not enough XAD cartridges for field spikes to calculate percent recoveries.

Standards ranging from 0.001 ppm to 1 ppm were prepared to construct a calibration curve for each PAH compound to calculate concentrations. The calibration curves for all PAH compounds can be found in Figure S2 of the Supporting Information. The limit-of-detection (LOD) and the limit-of-quantitation (LOQ) were calculated with aid from the LINEST function in excel which uses the statistical method of least squares. LOD and LOQ values can be found in Table S1 of the Supporting Information. Calibration was run at the beginning of every laboratory session to maintain accuracy.

## 2.5. Data Analysis

Line graphs were employed to visually represent variations in O<sub>3</sub>, CO<sub>2</sub> and PM<sub>2.5</sub> concentration levels during each sampling period. The dataset of obtained O<sub>3</sub> and PM<sub>2.5</sub> measurements at Secord Elementary School was enriched by integrating reference data from the Toronto East station, where unverified hourly data for O<sub>3</sub> and PM<sub>2.5</sub> was retrieved from Ontario's Ambient Air Monitoring Network.

Additionally, CO<sub>2</sub> concentrations were included in the analysis and plotted using a single line graph, presenting data for both weekdays and weekends. The reference data from the Toronto East station was consistent with the specific processing of Secord Elementary School data. O<sub>3</sub> and CO<sub>2</sub> measurements were averaged over 5-minute intervals, PM<sub>2.5</sub> data over 1-minute intervals, and CO<sub>2</sub> data for weekdays and weekends were averaged separately. Standard deviation calculations were applied to each mean data point to assess the variability in the measurements.

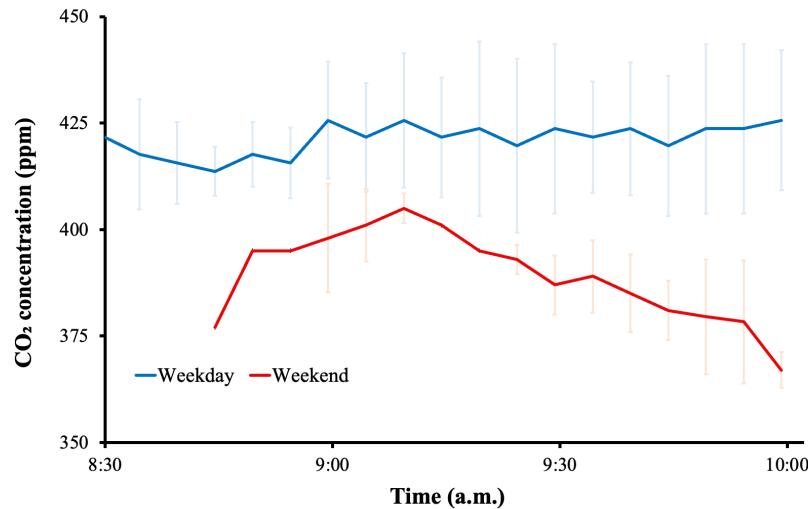
All graphs were generated using Microsoft Excel and portrayed time on the x-axis and concentration on the y-axis. This comprehensive approach facilitated a visual understanding of the temporal variations in O<sub>3</sub>, CO<sub>2</sub>, and PM<sub>2.5</sub> concentrations throughout the sampling periods.

### **3. Results and Discussion**

#### **3.1. Comparisons of Air Pollutants between Weekdays and Weekends**

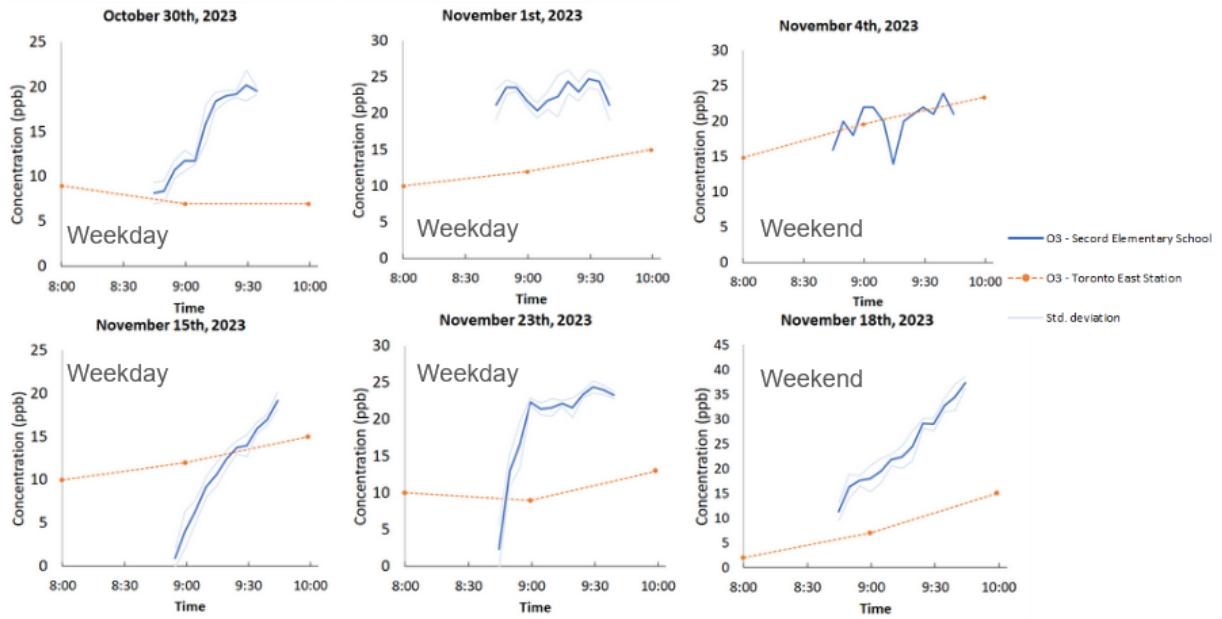
In the present study, air pollutants ( $O_3$ ,  $CO_2$ ,  $PM_{2.5}$ ) were monitored during weekdays and weekends to examine any significant differences. This was to determine if increased traffic on the weekdays would worsen the air quality experienced by children.

The observed  $CO_2$  levels as shown in Figure 3 demonstrate distinct variations in air quality throughout the drop-off period on weekdays and weekends. In particular, weekend  $CO_2$  levels dropped after 9:25 a.m. to 10:00 a.m.. This pattern is intriguing given that the first school bell rings at 8:45 a.m. when traffic near the school begins to lessen. The apparent delay in  $CO_2$  detection after the peak drop-off time suggests a lag in the sensor's ability to capture traffic-related  $CO_2$  changes. Furthermore, the lower  $CO_2$  levels during weekends could be attributed to the weather conditions on the days of sampling ( $n=2$ ). Factors like sunlight exposure, which enhances photosynthesis in plants, affect daily  $CO_2$  levels. Seasonal variations may have affected  $CO_2$  levels on both weekdays and weekends (Randerson et al., 1997), as data collection only occurred during the Fall-Winter season. During this time of the year, reduced photosynthesis and elevated respiration rates lead to generally higher ambient  $CO_2$  levels. Despite these variables, the  $CO_2$  measurements distinctly reflect the differences in traffic patterns between weekdays and weekends.



**Figure 3.** Ground-level CO<sub>2</sub> measurements on weekdays and weekends at Secord Elementary School. Standard deviation is calculated from 5 minute averages of 1 min frequency measurements to 95% confidence interval.

The time-series graphs in Figure 4 shows that on all days, O<sub>3</sub> concentrations increased between 8:45 am and 10:00 am. On October 30<sup>th</sup>, November 1st, November 15<sup>th</sup>, and November 18<sup>th</sup>, O<sub>3</sub> concentrations increased significantly, while November 1<sup>st</sup>, 4<sup>th</sup>, and 23<sup>rd</sup> increased slightly. There is no trend between weekends (November 4 and 18) compared to weekdays as November 4<sup>th</sup> increases slightly but November 18<sup>th</sup> increased significantly.



**Figure 4.** Ground-level  $O_3$  measurements on weekdays versus weekends at Secord Elementary School. Measurements at Secord Elementary School in blue and hourly data from Toronto East station in orange. Standard deviation is calculated from 5 min averages of 1 min frequency measurements to 95% confidence interval.

The trends observed may be a result of meteorology. The sampling time in this study coincides with sunrise and increasing sunlight, which could explain the increase in the observed  $O_3$  concentrations. However, all sampling was done after sunrise and all days except October 30th, had consistent weather conditions through the sampling time. Some days with sunny or clear skies and smaller hourly temperature changes between 8:00 - 10:00 a.m. coincided with days with no trend in ozone concentrations. However, not all days fit this trend.

To account for these differences, results were compared with background levels from the nearby Toronto East air quality station. Meteorological induced changes in sunlight and temperature would also be reflected in trends from the station. The increases on November 1<sup>st</sup> and November 23<sup>rd</sup> are in line with background increases. November 4<sup>th</sup> is interesting because

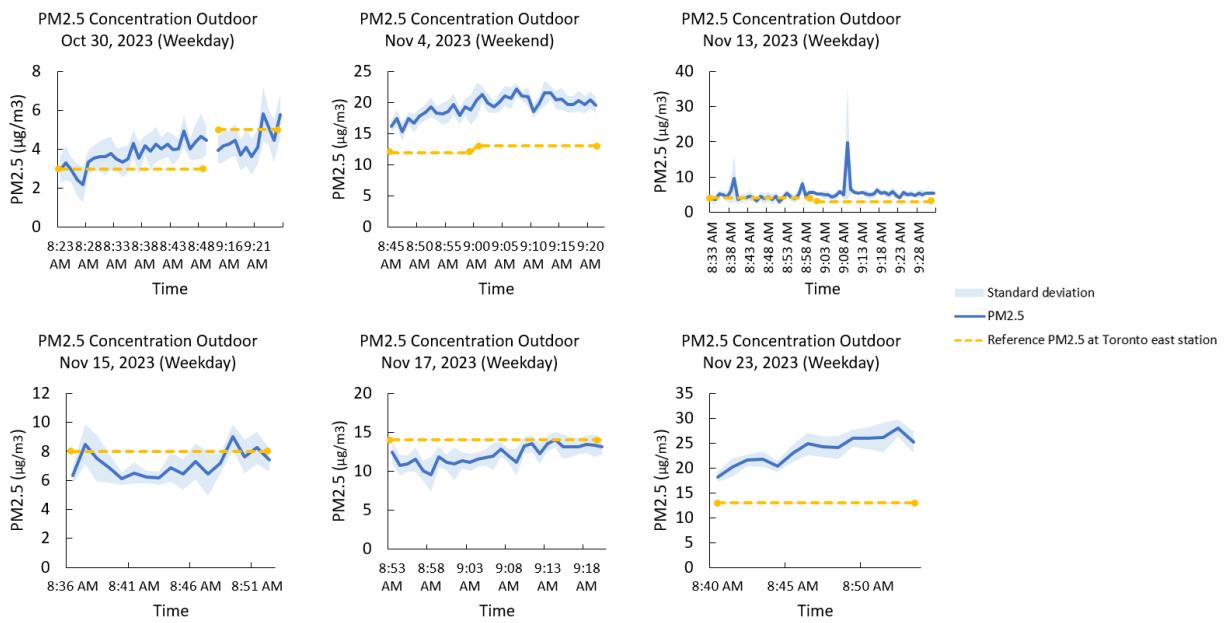
while measurements increased, background levels actually decreased. This was on a weekend as well, so results were not impacted by drop-off traffic. November 17<sup>th</sup> also increased slightly while background levels are stable at 30 ppb.

All measurements at Secord Elementary School were higher than background measurements. This is possibly because Secord is located in a more urban area than the station and subject to more primary pollutants being close to a high traffic corridor on Bloor Street and the regional GO train system lines. The urban heat island (UHI) effect can also intensify urban pollution through higher temperatures accelerating atmospheric chemistry cycles (Ulpiani, 2021). UHI can cause temperature-induced direct and indirect effects over O<sub>3</sub> pollution, including enhancement of O<sub>3</sub> photochemistry due to increased thermal decomposition of peroxyalkyl nitrates, a sink for nitrogen oxides, and enhanced evaporative hydrocarbon emissions from motor vehicles (Ulpiani, 2021). Temperature inversions can also reduce vertical mixing and “trap” pollutants in urban areas (Ulpiani, 2021). Temperature measurements at the sampling site and at the Toronto East station would be required to compare this hypothesis along with detailed modeling.

Instrument error is another possibility that caused the sharp increases on October 30<sup>th</sup>, November 15<sup>th</sup>, and November 18<sup>th</sup>. This current instrument has a long warmup time of 30 minutes to 1 hour and was not warmed up on days where a steep increase in concentration was observed at faster rates than background. However, the instrument was also not warmed up on November 4<sup>th</sup>, and this trend was not observed.

Overall, O<sub>3</sub> results are inconclusive but comparisons between weekdays and weekends with background levels indicate that traffic levels during drop-off are likely not significantly impacting ambient O<sub>3</sub> concentrations.

Figure 5 shows the PM<sub>2.5</sub> concentration profile near the dropoff locations during rush hours in the morning on weekdays between 8:00 and 10:00 a.m. and the concentration profile measured at the same location during the same period on weekends. The PM<sub>2.5</sub> concentration was measured every second but averaged to every minute when plotted, shown as a blue line with the blue shade area as the corresponding standard deviation. The reference PM<sub>2.5</sub> concentration, shown as the orange dashed line, was obtained from Toronto East air quality station near Scarborough, approximately 10 km east. The reference PM<sub>2.5</sub> concentration was to ensure the accuracy of the measurements and act as a background level.



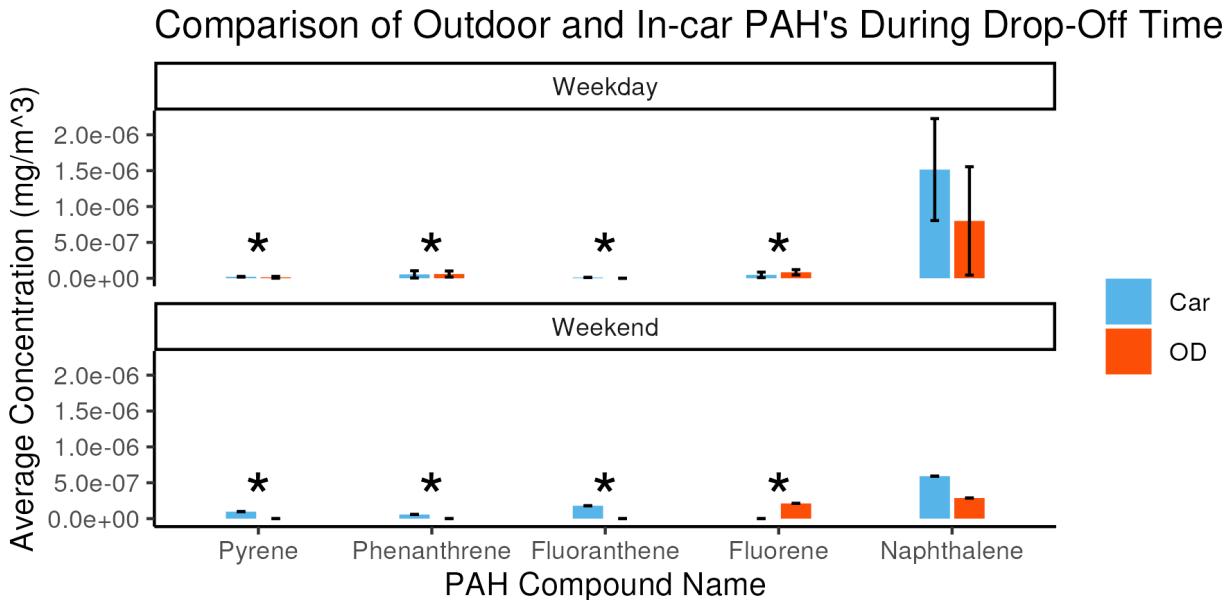
**Figure 5.** Outdoor PM<sub>2.5</sub> concentration near dropoff location at Secord Elementary School during rush hours on weekdays and on weekends.

It was expected to observe an increase in PM<sub>2.5</sub> concentrations during drop off hours on weekdays and attributed to the release of fine particles from vehicle emissions. Conversely, it was expected that PM<sub>2.5</sub> concentrations should remain relatively constant during weekends as there was considerably less traffic observed.

The PM<sub>2.5</sub> measurement near the school was relatively similar to the reference value from the nearby air quality station indicating good measurement quality. However, the PM<sub>2.5</sub> concentrations during dropoff hours on weekdays do not show a significant increase, highlighting fine particles released from car exhausts do not have a notable effect on overall PM<sub>2.5</sub> concentrations. It may be due to the traffic increase during the dropoff was not high enough to increase PM<sub>2.5</sub> concentrations in this area. Weather could have been a contributing factor as some sampling days were rainy and windy. Fine particles have the potential to be washed away by depositing into raindrops or diffusing to surroundings through wind.

### 3.2. Comparison of PAHs between Car and Outside on Weekdays and Weekends

PAH concentrations (mg/m<sup>3</sup>) were calculated by Equation S1 in the Supporting Information. Figure 6 illustrates the comparison of the arithmetic mean concentrations of PAHs in the outdoor and in-car environments, on weekends and weekdays. Values below the LOD are indicated using asterisks (\*).



**Figure 6.** Mean concentrations ( $\text{mg}/\text{m}^3$ ) and standard deviations of various PAHs outside (red) and in the car (blue) on weekends (lower) and weekdays (upper). The asterisk (\*) symbolize concentrations below the LOD.

The analysis of the partitioning of PAH compounds between the particulate phase and the gaseous phase play a crucial role during the evaluation of exposure to humans. Table S2 in the Supporting Information outlines the specific PAH compounds examined, their structures, and their vapor pressures at 25°C (PubChem, 2022). PAHs with higher vapor pressures, such as naphthalene, were expected to have greater gas phase partitioning than PAHs with lower vapor pressures, such as pyrene. The partitioning predictions are consistent with the trend displayed in Figure 6.

The rest of the PAH analysis will be for naphthalene as it was the only PAH to exhibit a concentration above the LOQ. Additionally, the weekend data were based on measurements taken from a single day, therefore a Grubbs test for all days at the 95% confidence interval was performed using R to determine if the weekend data was an outlier. The null hypothesis is that

the outdoor and in-car data contains no outliers. The p-values for in-car and outdoor data were 0.70 and 0.086, respectively. These are higher than the defined significant level, therefore there is not enough evidence to reject the null hypothesis.

A two-tailed t-test was performed at the 95% confidence interval for weekday naphthalene concentrations using R. The null hypothesis suggests that there is no difference in the mean naphthalene concentrations between the in-car and outdoor environments during weekdays. The calculated p-value was 0.217 which is greater than the defined significant level, therefore there is not enough proof to reject the null hypothesis. Despite the limitations of the statistical analysis, naphthalene concentrations in the in-car environment were qualitatively higher than in the outdoor environment with both larger during weekdays, suggesting nearby emissions may be a contributing factor.

A study by Alkurdi et. al examined the emission rates of individual PAH compounds. It should be emphasized that the car used in the current study, a 2018 1.6T Hyundai Kona, was a much newer vehicle than the newest vehicle in the study by Alkurdi et. al, a 2008 Hyundai Avante. Alkurdi et. al (2013) found the most prominent PAH to be naphthalene in all vehicle models which is consistent with the results of the current study. Additionally, their data did not reveal an observed trend between PAH emissions, other than naphthalene across models. However, it was observed that older vehicles, in general, exhibited much higher emission rates for all compounds, demonstrating PAH emissions may vary depending on vehicle types (Alkurdi et al., 2013).

Health Canada has established the maximum long-term exposure limit in which no adverse health effects should occur and is  $0.010 \text{ mg/m}^3$ . The average naphthalene concentrations in Canadian homes have been found to range from  $3.0 \times 10^{-4}$  to  $6.3 \times 10^{-3} \text{ mg/m}^3$  (Canada, 2014).

The naphthalene concentrations in mg/m<sup>3</sup> for the outdoor and in-car environments are shown in Table S3. Concentrations in Table S3 do not exceed the levels observed in a typical home environment and are within safe limits, therefore, exposures are unlikely to cause any health effects.

#### **4. Conclusions and Future Work**

There was no significant difference in outdoor air quality on weekdays compared to the weekends due to drop-off of children near Secord Elementary School. CO<sub>2</sub> levels were slightly higher on weekdays, but trends in ground-level O<sub>3</sub> and PM<sub>2.5</sub> were not observed. PM<sub>2.5</sub> and ground-level O<sub>3</sub> were generally higher than measurements made by the Toronto East station, reflecting the strong local variation in air pollution that can occur potentially due to differences in pollution emission and urban heat island effect.

Out of all the PAHs, only naphthalene was above the limit of detection measured outside and inside the car. Naphthalene concentrations were higher on weekdays versus the weekends, and higher inside the car versus outdoor air. Contrary to intuition that those inside the car would be in an isolated or pristine environment, the results indicated that vehicle self-pollution has a potential to worsen air quality and increase exposure to passengers. However, these results are highly dependent on car type, fuel, and air circulation within the car. In this study, the windows were closed and had the heating on to mimic conditions parents might use for their children during this time and season.

The results suggest children should walk or bike instead of being driven in a vehicle. Not only will this limit their own exposure to pollutants like naphthalene, it will also reduce the amount of overall air pollution in the area that increases exposure for the entire community.

Future studies can continue to investigate vehicle self-pollution outside of PAHs. For example, O<sub>3</sub>, NO<sub>2</sub>, and CO can be measured in the gas phase, in addition to aerosol exposure to PM<sub>2.5</sub> and PM<sub>10</sub>. Outdoor air monitoring can be improved by simultaneous measurements in the same neighborhood away from the school traffic and at the school to better capture the air pollution effects specifically due to drop-off. Additional weekend replicates can also improve our conclusion that PAH levels were different between weekends and weekdays. Individual passive samplers given to students while they commute can also better accurately reflect exposure levels. Cycling was also not investigated in this study. Finally, modeling of exposure can be completed that includes all potential contaminants instead of just naphthalene exposure, to better inform the risk that driving poses.

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Witschi, H. (1988). Ozone, nitrogen dioxide and lung cancer: A review of some recent issues and problems. *Toxicology*, 48(1), 1–20. [https://doi.org/10.1016/0300-483x\(88\)90054-6](https://doi.org/10.1016/0300-483x(88)90054-6)

## 6. Supporting Information

a.



b.

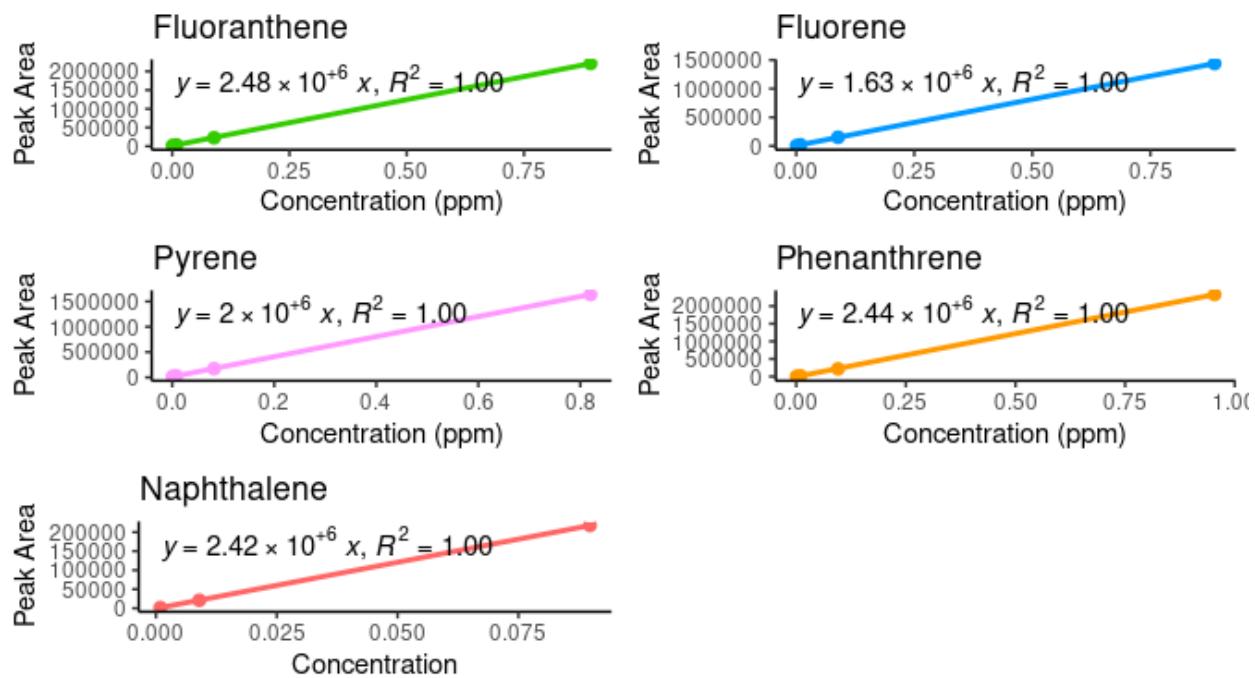


c.



**Figure S1.** a) Air pumps used for PAH sampling b) Aeroqual monitors for CO<sub>2</sub>, O<sub>3</sub> and c) PM<sub>2.5</sub> monitoring.

## Calibration of PAHs



**Figure S2.** Linear gas chromatography (GC) calibration curves for **a)** fluoranthene, **b)** fluorene, **c)** pyrene, **d)** phenanthrene, and **e)** naphthalene.

**Table S1.** Limit-of-detection (LOD) and limit-of-quantitation (LOQ) for analyzed PAHs.

Compound	LOD	LOQ
Naphthalene	$2.84 \times 10^{-4}$	$9.47 \times 10^{-4}$
Fluorene	$3.56 \times 10^{-3}$	$1.19 \times 10^{-2}$
Phenanthrene	$1.08 \times 10^{-2}$	$3.59 \times 10^{-2}$
Fluoranthene	$7.80 \times 10^{-3}$	$2.60 \times 10^{-2}$
Pyrene	$5.36 \times 10^{-3}$	$1.79 \times 10^{-2}$

**Equation S1.** Conversion of PAH concentrations from ppm (in GC-vial) to mg/m<sup>3</sup>.

$$PAH \text{ conc. (mg/m}^3 \text{)} = \frac{(PAH \text{ sample(ppm)} - PAH \text{ blank(ppm)}) * \text{dilution(0.002 L)} * \text{time(60 mins)} * \text{flow rate (L/min)}}{1000 \text{ L/m}^3}$$

**Table S2.** Vapor pressures of analyzed PAH structures at 25°C (PubChem, 2022).

Compound	Structure	Vapor Pressure (mm Hg) at 25°C
Naphthalene		8.5 *10 <sup>-2</sup>
Fluorene		6.0*10 <sup>-4</sup>
Phenanthrene		1.21*10 <sup>-4</sup>
Fluoranthene		9.22*10 <sup>-6</sup>
Pyrene		4.5*10 <sup>-6</sup>

**Table S3.** Mean in-car and outdoor naphthalene concentrations during weekdays and weekends.

In-car or Outdoor	Weekday or Weekend	Mean concentration (mg/m <sup>3</sup> )	Standard deviation (mg/m <sup>3</sup> )
Car	Weekend	5.92*10 <sup>-7</sup>	0.00

Outdoor	Weekend	$2.87 \times 10^{-7}$	0.00
Car	Weekday	$1.51 \times 10^{-6}$	$7.10 \times 10^{-7}$
Outdoor	Weekday	$7.99 \times 10^{-7}$	$7.55 \times 10^{-7}$