LV Breathes December 2025 Newsletter
Data Snapshot

Overview

For this month's *Lehigh Valley Breathes* Newsletter, we provide another snapshot of our data from a dozen monitors that were running during the month of February 2024. Because this month is in the winter, there are distinct atmospheric conditions that impact the dispersion of fine particulate pollution ($PM_{2.5}$), as well as additional sources of $PM_{2.5}$ in areas where wood stoves are used for heating. We discuss these conditions when we think they might be most relevant to our initial observations of the data. The geographic areas that we compare are in varying proximity to major highways and roadways in the Valley's urban corridor, and on rural roads with varying levels of truck traffic. Several key findings stand out in our initial analysis:

- While average levels of $PM_{2.5}$ pollution in the month of February 2024 varied across the twelve locations by nearly 4 micrograms per cubic meter of air ($\mu g/m^3$), the monitor located at the government's air monitoring station in Freemansburg, Pennsylvania had the lowest average level of $PM_{2.5}$ pollution. This underscores the limitations of current air pollution data from the government, which samples $PM_{2.5}$ pollution at only two monitoring stations in the Lehigh Valley. Specifically, our data show that many areas of the Valley have significantly higher levels of $PM_{2.5}$ pollution than the level measured by our monitor that is co-located at the government's air monitoring station in Freemansburg.

- Some rural roads experiencing high levels of truck traffic have levels of $PM_{2.5}$ pollution that are higher than $PM_{2.5}$ pollution in urban locations that are within half a mile of major highways. Some rural areas are also experiencing a pollution burden greater than urban corridor areas that are proximate to major roadways that also have much higher levels of daily traffic.

- $PM_{2.5}$ pollution levels measured by monitors that are located between 150 meters and half a mile of highways or that are proximate to (or within 150 meters of) major roadways vary in relation to traffic volume and distance from it. While there may be other factors besides traffic contributing to pollution in these locations, a preliminary look at traffic volume and distance appears to provide some explanation for the variation in $PM_{2.5}$ pollution.

Monitor Locations

The location of each monitor discussed in this data snapshot is described in the table below.

Monitoring Site Designation	Monitor Name	Monitor Location Description
NEAR HIGHWAY MONITORS (between 150 meters and .5 miles from a highway)	NorthBeth22	Urban corridor area in a residential neighborhood with little traffic but less than .5 miles from Highway 22
	78-22KT	Urban corridor area in residential neighborhood with little traffic but less than .5 miles from Highway 78
	LCC-309	Urban corridor area in residential area but approximately 365 feet from Route 309
	222-YE	Urban corridor area in residential neighborhood that is .4 miles from Route 222
	West78-BB	Urban corridor area in residential neighborhood but less than a quarter mile from Highway 78
PROXIMATE TO MAJOR ROADWAY MONITORS	KingKone	Urban corridor area that is proximate to a busy roadway (Route 145/MacArthur BLVD)
	StefkoMMA	Urban corridor area proximate to a busy roadway (Stefko BLVD in Bethlehem)
URBAN PARK MONITORS	HokeyPark	Park in urban corridor area that is just over .5 miles from Route145/MacArthur BLVD)
	Freemansburg	Park in urban corridor area that is north-northwest of Bethlehem Industrial Park but not near a major highway or roadway
RURAL ROAD MONITORS	Lower-MT-Bethel	Rural area in a residential neighborhood that is proximate to road with truck traffic
	Mt-Bethel-611	Rural area in a residential neighborhood that is proximate to road with truck traffic
	Allen-RuralLB	Rural area in a residential neighborhood that is proximate to two roads with truck traffic

Daily average $PM_{2.5}$ concentrations across 12 locations in February 2024

As depicted in **Figure 1** (below), average levels of $PM_{2.5}$ pollution measured during the month of February 2024 varied from a low of 8.1 µg/m^3 to a high of 11.9 µg/m^3. The locations with the highest average Level of $PM_{2.5}$ pollution are Allen-RuralLB (11.9 µg/m^3), Lower-Mt-Bethel (11.8 µg/m^3), and West78-BB (11.8 µg/m^3). The locations with the lowest average level of $PM_{2.5}$ pollution are Freemansburg (8.1 µg/m^3), Mt-Bethel-611 (8.1 µg/m^3), and 222-YE (8.7 µg/m^3).

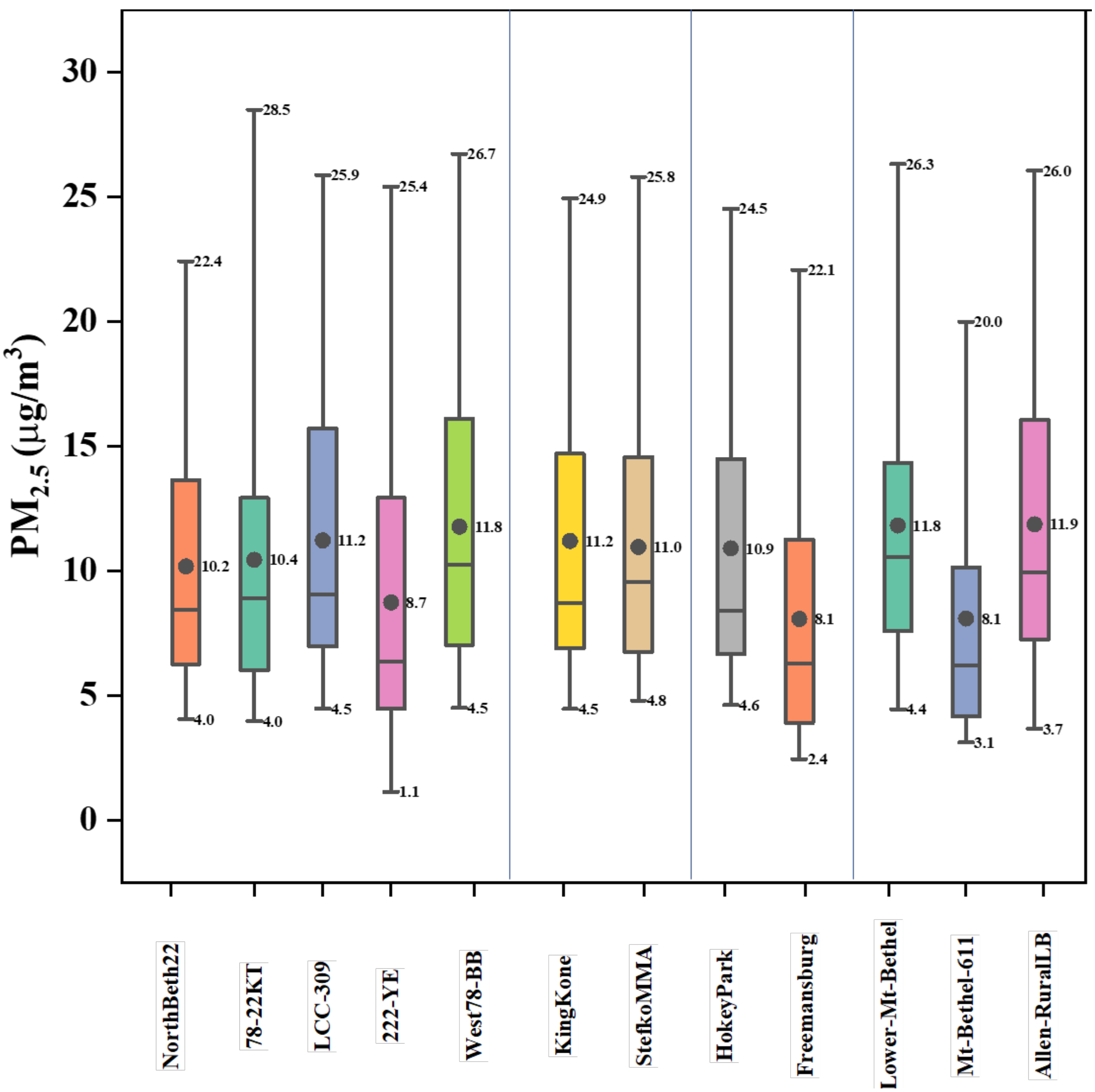

Figure 1: $PM_{2.5}$ concentration variation across monitoring locations

The high levels of $PM_{2.5}$ pollution in two of the rural areas (**Allen-RuralLB** and **Lower-Mt-Bethel**) are notable because although residents in these locations requested that we monitor there due to high amounts of truck traffic, we did not expect the $PM_{2.5}$ levels to be as high as in areas near highways, such as **West78-BB**, which is .2 miles from a highway that has an average daily a traffic volume of over 66,000 vehicles. It is possible that some of the particulate pollution burden in these rural areas is created by wood stove use in the winter months, so in our broader data analysis, we will be assessing how these comparisons between near-highway and rural road areas change on a seasonal basis. It is also notable that these two rural locations are on roads where there is a significant elevation/gradient change, which means that daily acceleration and braking by trucks may be contributing to higher levels of $PM_{2.5}$ pollution.

One rural location **– Mt-Bethel-611 –** in the month of February 2024 has comparably low $PM_{2.5}$ levels. Although this location is also on a road with a lot of truck traffic, we placed a monitor there at the request of community members who were worried about an expected increase in traffic that might result from development of a nearby Industrial Park. Thus, the currently collected data will provide a baseline for expected increases in $PM_{2.5}$ pollution in the future. Unlike the other two rural areas with higher $PM_{2.5}$ levels, Mt-Bethel-611 is not on a road with a steep elevation/gradient change.

The other two locations with lower levels of $PM_{2.5}$ pollution are Freemansburg and 222-YE. The **Freemansburg** location is removed from major roadways and highways, on the edge of an urban park. The air monitor in this location is co-located at the Pennsylvania Department of Environmental Protection's air monitoring station and therefore provides a way of assessing how the air quality where the government is sampling air compares to other areas in the Valley. In the month of February, the Freemansburg monitor measured the lowest levels of $PM_{2.5}$ pollution among all the monitors we assessed for this data snapshot. This suggests that air quality at the government monitoring site during the month of February 2024 is not representative of what people are breathing in other areas of the Valley. **222-YE** is located almost half a mile from Route 222. Among the monitors that are located between 150 meters and .5 miles from a highway, this monitor has comparatively low levels of $PM_{2.5}$ pollution during the month of February 2024. For example, NorthBeth22, which is similarly located .4 miles from Highway 22, has an average level of 10.2 $\mu g/m^3$, compared to an average of 8.7 $\mu g/m^3$ at 222-YE. Annual average daily traffic of Highway 22 is much higher (72,699) than on Route 222 (39,808), which may explain some of the difference in $PM_{2.5}$ levels.

The remaining locations we analyzed for in this data snapshot are all in the urban corridor. Like 222-YE, the LCC-309, NorthBeth22, and 78-22KT monitors are all located between 150 meters and .5 miles of a highway and have daily average $PM_{2.5}$ levels that vary from each other by less than 1 $\mu g/m^3$ (between 10.2 $\mu g/m^3$ and 11.2 $\mu g/m^3$). Notable, however, is that the locations that are proximate to or relatively near heavily trafficked roadways in the urban corridor (StefkoMMA, KingKone, and HokeyPark) are also within this range of $PM_{2.5}$ pollution. Among these three locations, the **HokeyPark** location has the lowest levels (10.9 $\mu g/m^3$) of average $PM_{2.5}$ pollution in February 2024. Although this monitor is parallel to an area of Route145/MacArthur BLVD that has an annual average daily traffic volume of 23,091 vehicles, it is more than half a mile from this roadway. In contrast, the **Stefko** and **KingKone** locations are proximate to heavily trafficked roadways and have slightly higher average $PM_{2.5}$ levels. Specifically, the Stefko location, with a daily annual average traffic volume of 9,909, has an average $PM_{2.5}$ level of 11 $\mu g/m^3$. The KingKone location, with a daily annual average traffic count of 11,663, has an average level of $PM_{2.5}$ of 11.2 $\mu g/m^3$.

Diurnal Patterns in $PM_{2.5}$ Pollution at *Near Highway* and *Proximate to Major Roadway* Urban Corridor Locations

Although the low-cost Purple Air monitors that we are using to measure pollution do not distinguish among different types of particle pollution and therefore among their sources, diurnal patterns in the data do provide hints about how pollution might be related to traffic. The diurnal patterns in the data in the charts below show average levels of $PM_{2.5}$ by each hour of the day, averaged over the whole month of February 2024. They reveal how changes in $PM_{2.5}$ may be related to rush-hour periods, or other times of the day when tractor trailer trucks may be more dominant on the road. Diurnal patterns can also reveal the influence of meteorological factors like temperature inversions that are related to times of day when temperature changes more or less dramatically.

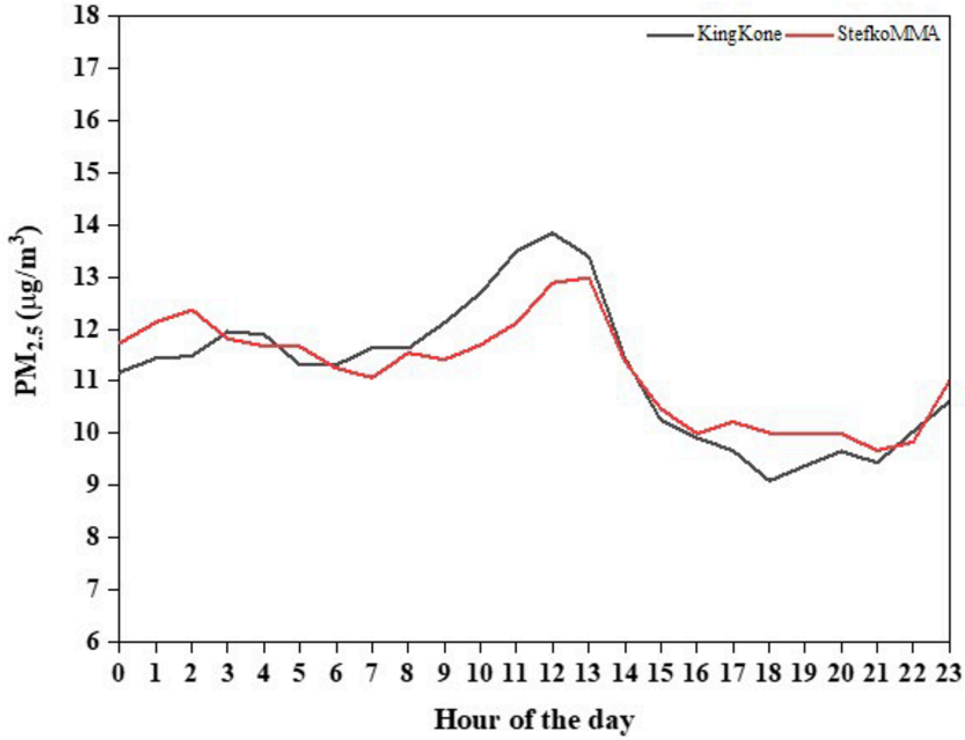

Figure 2: Diurnal patterns in KingKone and StekoMMA locations

As depicted in **Figure 2** above, the diurnal pattern of pollution at the two monitors that are *proximate to major roadways* (**StefkoMMA** and **KingKone**) in the urban corridor show highly similar fluctuations in $PM_{2.5}$ pollution. Both locations have moderate concentrations of $PM_{2.5}$ in the early morning, after which levels rise gradually when commuter activity is likely to increase. This upward trend continues into the late morning and early afternoon, when both locations hit their peak concentrations. The KingKone location shows a slightly sharper and higher midday rise in $PM_{2.5}$ than the Stefko location. This may be due to a slightly stronger localized traffic volume at the KingKone location, which is on a roadway with an annual average daily traffic volume of 11,633 vehicles, in comparison to the 9,909 annual average daily traffic volume at the StefkoMMK location. Following this midday maximum, concentrations at both locations decline quickly, possibly driven by greater atmospheric mixing of the pollution particles and a partial decline in traffic volume. Evening concentrations in both locations remain lower and more stable with nearly overlapping values. The synchronized timing and closely aligned peaks in these distinct locations suggest uniformity in the pattern of emission on major roadways in the urban corridor.

The diurnal patterns conveyed in **Figure 3** below show a broadly similar temporal structure across the *urban corridor near highway* sites. All sites begin with relatively low early-morning concentrations of $PM_{2.5}$, after which levels increase steadily from approximately 5:00-6:00 a.m. onward, coinciding with the onset of morning commuter traffic. **West78-BB** rises most sharply during this period, maintaining the highest concentrations across the morning and mid-day hours, consistent with its previously identified elevated daily traffic volume average of over 66,000 vehicles; this location is also within .5

miles of the Valley's largest Industrial Park. **LCC-309** and **78-22KT** follow closely, showing pronounced mid-day peaks between late morning and early afternoon, which suggests sustained highway emissions and possible contributions from heavy-duty vehicle flows. **NorthBeth22** exhibits a moderate yet consistent rise through the morning hours, while **222-YE** remains the lowest throughout most of the day, reaffirming its relatively less-impacted microenvironment within the near-highway category of monitors. After the early-afternoon peak, all sites show a marked decline beginning around 3:00-4:00 p.m., which may be due to improved atmospheric mixing of the pollution particles at this time of day, when solar heating of the earth's surface creates atmospheric instability that allows for greater dispersion of $PM_{2.5}$ pollution. Evening levels remain comparatively lower across all sites, indicating that nighttime reduction in traffic outweighs the simultaneous decrease in atmospheric mixing of particles at this time of the day.

Overall, the synchronized timing across *urban corridor near highway* locations suggests the impact of roadway emissions and atmospheric dynamics that determine how easily pollution particles mix and disperse in the air, while the magnitude of differences between locations suggests the impact of local roadway configuration, traffic volume, traffic type, and micro-scale features of the environment that may impact pollution dispersion.

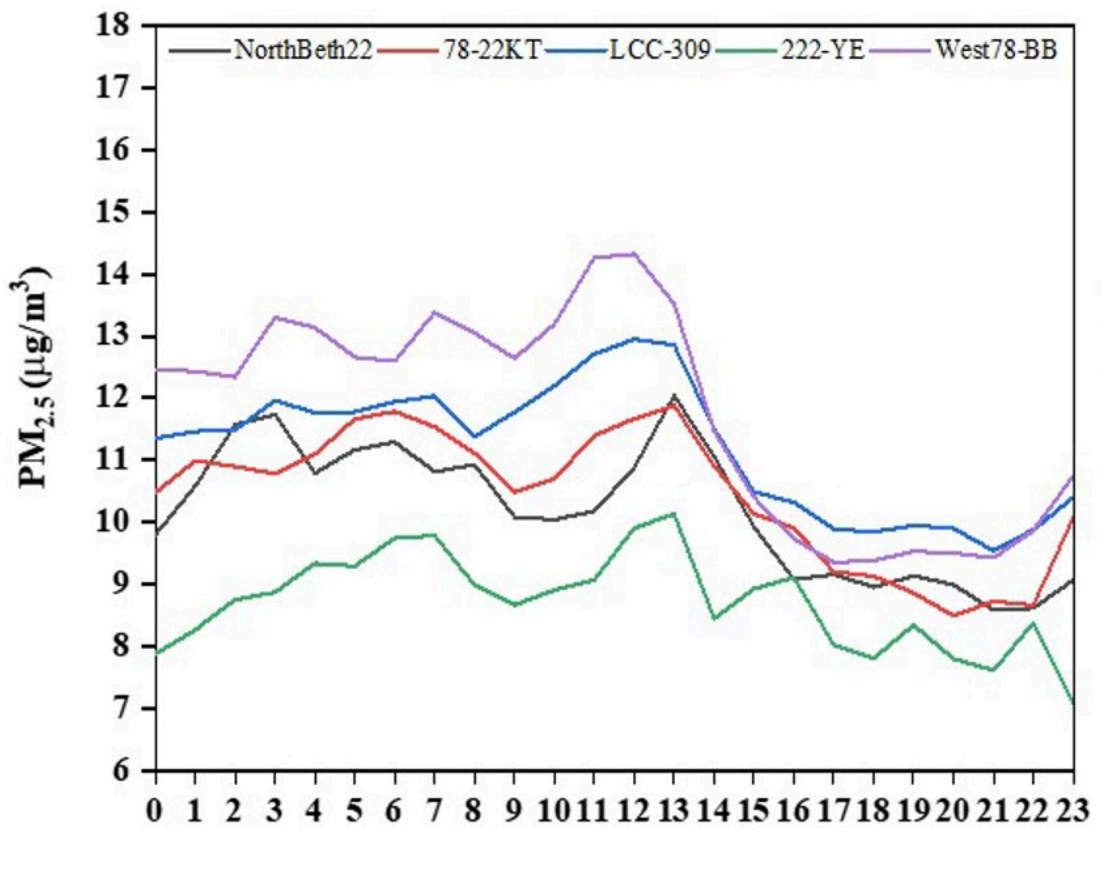

Figure 3: Diurnal patterns in urban corridor near-highway locations