Air Quality in Harrisburg, PA

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Executive Summary

Air quality has become more of a prevalent concern in the country as research shows increasingly strong correlation between pollution and health. Fine particulate matter, or PM_{10}, is one of the pollutants monitored in the Clean Air Act and is one of the most detrimental pollutants to long term health. While Harrisburg is currently meeting the standards of the CAA and has made remarkable progress during the last 15 years, there is reason to believe that when the policy is next revised within the next 5 years, regulations will follow the trend of having stricter standards and the city will once more have to address its emissions. An analysis of EPA data indicates that the two major sources of PM_{10} near the city's air quality monitoring site are the Susquehanna Resource Management Complex and the Brunner Island power plant, both of which can be mitigated with intelligent, directed interventions, leading to cleaner air and better health for the residents of Harrisburg.

Introduction

Air quality has become more of a prevalent concern across the United States and has especially resonated with Pennsylvania as research shows increasingly strong correlation between pollution and health. The economy of the state is rooted in industrial production and manufacturing [2] and thus has the potential to be exposed to high levels of PM_{10}, which implicates the health of the state's citizens. If each city or town is addressed individually by its political leaders, these pollutant levels would decrease and thus positively impact the the wellbeing of the surrounding environment and the people.

As both the capital of Pennsylvania and a historically industrial city, Harrisburg offers the perfect opportunity to improve the health outcomes of Pennsylvania citizens

and set an example for the rest of the state through targeted and intelligent policies to decrease harmful air pollution. While Harrisburg is currently meeting the standards of the Clean Air Act (CAA), there is reason to believe that when the policy is next revised for the year 2020, standards will continue to follow the trend of previous amendments and become even stricter, forcing the city to once more address its emissions [3]. Analysis of pollutant data collected by the Pennsylvania Department of Environmental Protection can be used to understand the largest point sources of pollutant PM_{10}, enabling targeting interventions towards those point sources as to improve health effects across the city.

The Environmental Protection Agency has been observing the constant stream of academic studies to make adjustments to the national air quality standards through the CAA every 5 years, the most recent of which was in 2015. Fine particulate matter, or PM_{10} comprised of inhalable particulate under 10 micrometers in diameter, is one of the pollutants monitored in the CAA and is one of the most detrimental pollutants to long term health. This pollutant is especially harmful because human physiology has few mechanisms for removing the pollutant once it has entered the lungs. Air pollution caused 6% of total mortality, more than 40,000 attributable cases per year. About half of all mortality caused by air pollution was attributed to motorised traffic, accounting also for: more than 25,000 new cases of chronic bronchitis (adults), more than 290,000 episodes of bronchitis (children), more than half a million asthma attacks, and more than 16 million person-days of restricted activities. [1].

Results and Interpretation

Using a large amount of PM_{10} data from the air quality monitoring site located in Harrisburg, we found that annual average PM_{10} concentration in Harrisburg decreased during the duration of the study from 22 $\mu g/m^3$ in 2001 to 17 $\mu g/m^3$ in 2011, with the biggest decrease between 2008 and 2009 (Figure 1.1). A potential explanation behind this drastic change in emissions could be the change in politicians. Mayor Stephen Reed had been the mayor for 30 years, 1981 to mid-2009, and was arrested on

corruption charges for not properly allocating or managing resources, misplacing audits, and conducting convoluted transactions, including swap agreements [4,5]. This raises the question of whether or not pollution emissions from generators and factories in Harrisburg were adhering to regulations that correlate to the concentrations displayed in the graph. If so, since the mayor's arrest, Harrisburg has made drastic improvement and can implement policies or procedures from this study to continue to improve. Additionally, we suspect that there were further surrounding circumstances that resulted in the drastic emissions reduction from 2008 to 2009.

In order to further understand the character of PM_{10} concentrations, the diurnal cycle of PM_{10} was analyzed and averaged over the entire dataset. Concentrations remain nearly steady at 19 $\mu g/m^3$ for most of the day, with the notable exception of a sharp spike in concentrations beginning at 10:00am, peaking near 23 $\mu g/m^3$ at noon (Figure 1.2).

Examining the seasonality of PM_{10}--by averaging the measured quantities over the course of a day for every three months--shows that there is significant seasonal variation in overall levels of particulate matter, but the shape and magnitude of the 12:00 peak does not appear to vary significantly with the seasons (Figure 1.2). Additionally, the maximum of the peak occurs between 11:00 and 12:00 in all four seasons, although overall PM_{10} levels are the lowest in the winter and highest in the summer.

Because this peak is so well-defined and consistent between seasons, we believe that it reflects a specific source, rather than boundary layer dynamics. As such, the most likely explanation for this peak is a single large particulate matter source in the vicinity of the measurement site that is specifically active during that time period. This implies that a natural origin of the sharp spike is unlikely, due to the four-season climate of Harrisburg, and it is most likely the result of a single large industrial or commercial particulate source.

In order to further investigate the potential of an industrial source of this pollution, we used gaussian dispersion modelling, which suggests that the major pollution source

coming from the west is the waste incinerator, located only 0.4 miles away from the monitoring site. Dispersion modeling also provides evidence that the main source of pollutants from the south are coming from the Brunner Island electricity generator, located 13 miles southwest. Figure 1.5 shows the resulting plume shape from the incinerator on a typical summer day in the Harrisburg area. Maximum concentrations at the site reach 12 $\mu g/m^3$, very close to the 15 $\mu g/m^3$ measured in air from the west as shown in Figure 1.7. This indicates that PM_{10} emissions from the incinerator site likely explain a significant fraction of the ground-level pollutant concentration observed when wind is coming from the west. Figure 1.6 in tandem with Figure 1.7 model indicates that peak concentrations at the measurement site are be 18 $\mu g/m^3$ from the southwest which represents a substantial fraction of the 22 $\mu g/m^3$ observed in available data. This indicates that the Brunner Island power plant, even though it is located several miles outside of Harrisburg, can still account for a significant fraction of the pollution in the city on days with particularly unlucky meteorological conditions. These two point sources explain the peaks displayed in the diurnal cycles as well as the seasonal diurnal changes. Harrisburg is exposed to the PM_{10} emissions created by these two industrial point sources, which has the potential to lead to serious health detriments.

Recommendations

When the next CAA regulations are created, they will be more rigid and create a lower ceiling on pollutants [3, 6]. There are various policy options that the municipal government can implement in order to keep PM_{10} emissions within regulations when the changes to the act are made. We believe that Harrisburg has a clear path to remaining in compliance with future regulations, as well as improving health outcomes, by rethinking and making improvements in both policy and technical solutions.

The Brunner Island power plant, because it represents such a large portion of particulate emissions in the Harrisburg area, represents a compelling target for improvements. Because the PM_{10} from the plant mostly reaches the densely populated Harrisburg metropolitan area when the wind is blowing from the south, health-aware

power grid management policies that intelligently shift power generation to the nearby Three Mile Island generating facility during periods of forecasted southerly winds promise to provide substantial health improvements at low cost [8]. Additional study is required to fully understand the impact of shedding generation capacity in this way, and we are hopeful that the presence of emissions-free nuclear generation nearby will allow this dynamic rebalancing to be performed cheaply and rapidly. Because this is a policy change impacting the operating companies of both facilities, close cooperation with commercial interests will be required, but the potential health benefits to Harrisburg residents are significant enough that we believe it is worth pursuing.

Additionally, the fact that the Susquehanna Resource Management Complex (SRMC) incinerator is a major source of dangerous particulate pollution in the Harrisburg area indicates the importance of it is important to focusing emissions reduction efforts on public works facilities as well as privately owned industrial operations. The Lancaster County SWMA, which operates the SRMC complex, has invested millions of dollars in aesthetic and community-relations improvements for the SRMC since 2014 [7], and we believe there would be substantial benefit from investing similarly in emissions controls measures, likely including scrubbing and combustion technology improvements, as well as community engagement to better filter the kinds of waste burned at the facility. In addition to having a significant effect on community health, the corresponding reduction in emissions acts as a beacon to the community that their waste is being handled responsibly, sending a positive message and setting a good example for other cities in Pennsylvania and across the country.

Conclusion

Air quality standards have the potential to improve across Pennsylvania. An example of this is Harrisburg, PA, where PM_{10} emissions have improved drastically in the span of eleven years, from 22 $\mu g/m^3$ in 2001 to 17 $\mu g/m^3$ in 2012. However, it is evident that the Susquehanna Resource Management Complex and the Brunner Island power plant are still heavy industrial polluters in the city, and provide an opportunity for

further emission reductions to be made. This would improve the health and wellbeing of those citizens in the long run. Taking the preventive steps towards PM_{10} emissions allows Harrisburg a leader in this pursuit of better air quality and a strong example for other states to follow.

Works Cited

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Supplementary Information

Table 1.1 - Major Industrial Pollutant Sources in Harrisburg in 2011[1]

Source name	Source Type	Location	PM_{10} (tons)	$PM_{2.5}$ (tons)	Distance from Site
ARCELORMITTAL STEELTON LLC/STEELTON	Steel Plant	215 S FRONT ST STEELTON PA	29	27	1.4 miles SSW
LANCASTER CNTY SWMA/SUSQ RESOURCE MGMT COMPLEX	Municipal Waste Combustor	1670 S 19TH ST HARRISBURG PA	30	28	0.4 miles West
BRUNNER ISLAND LLC/BRUNNER ISLAND	Electricity Generation	1400 WAGO RD YORK HAVEN PA	1548	753	13 miles SW
NRG ENERGY CTR PAXTON LLC/HARRISBURG	Steam regional heating plant	100 N 10TH ST HARRISBURG PA	6.43	6.41	2 miles NW

[1] TO DO: cite polluter data from EPA (https://www3.epa.gov/air/emissions/where.htm)

Figure 1.1 - Average yearly concentrations from 2001 to 2011

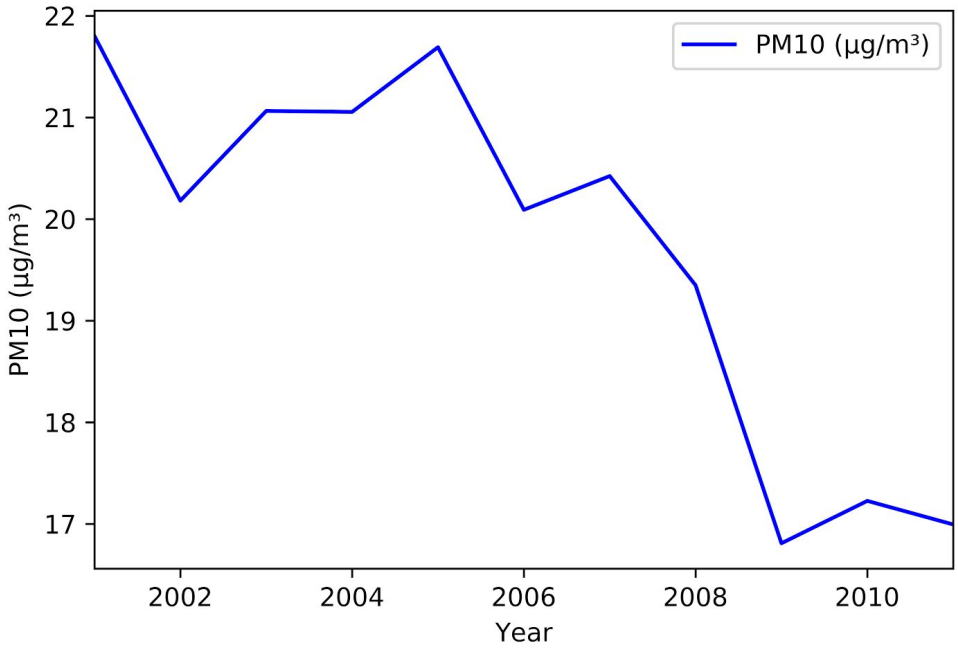

Figure 1.2 - Seasonal Diurnal Concentrations of PM_{10}

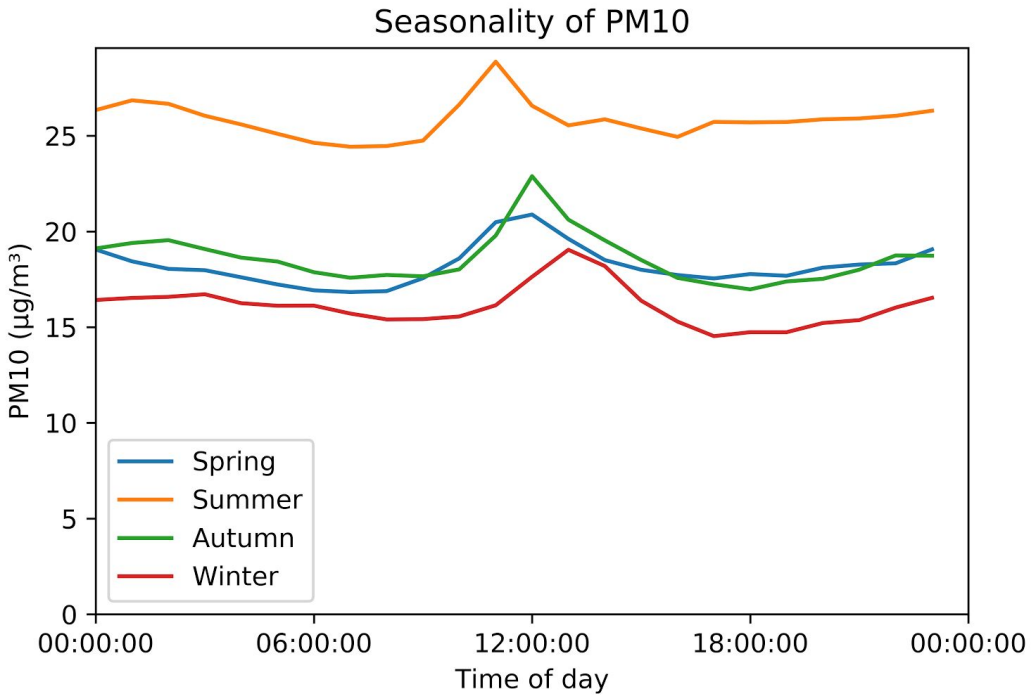

Figure 1.4 - Diurnal Concentrations of PM_{10}

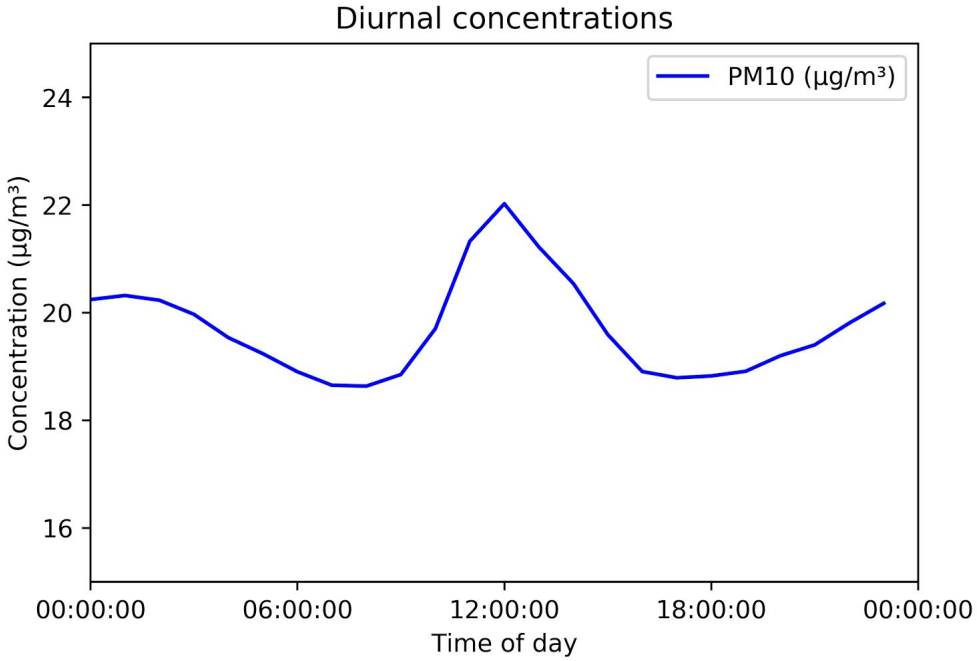

Figure 1.5 - Dispersion from incinerator

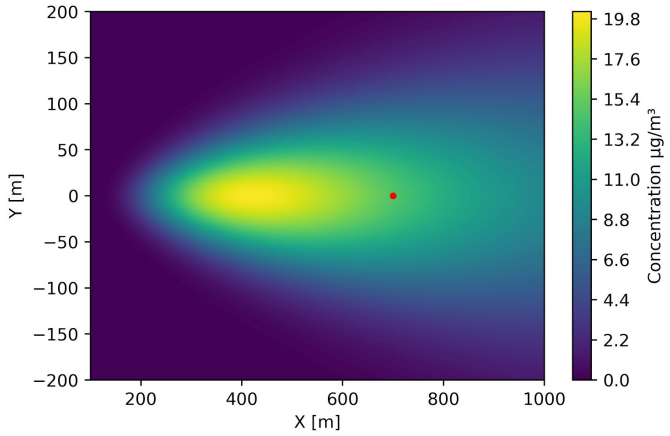

Figure 1.6 - Dispersion from coal plant

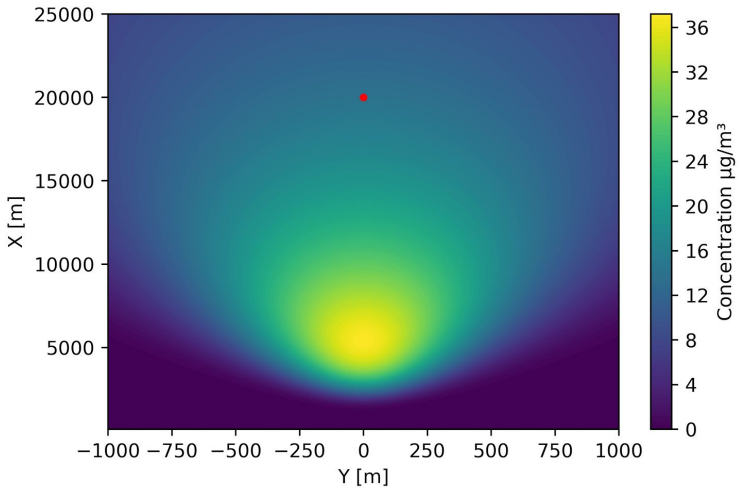

Figure 1.7 - Windrose plot