Seasonal Report

2020 Fine Particles ($PM_{2.5}$)

OVERVIEW

Maryland continued to demonstrate attainment for fine particles, also known as $PM_{2.5}$, in 2020. $PM_{2.5}$ is unique as it is not dependent on sunshine and warm temperatures like ground level ozone. This allows $PM_{2.5}$ to develop year round, although the winter months are typically when Maryland experiences its highest concentrations in recent years. Given its small size (<2.5µm in diameter), these airborne particles are able to penetrate deep into the lungs resulting in adverse cardiovascular effects including asthma attacks, acute bronchitis, and increased susceptibility to respiratory infections to name a few. $PM_{2.5}$ is one of six pollutants which have a National Ambient Air Quality [Health] Standard (NAAQS) set by the Environmental Protection Agency (EPA). When the midnight to midnight daily 24-hour average $PM_{2.5}$ concentration exceeds 35.4 µg/m^3 or 100 on the Air Quality Index (AQI) (see bottom page) it is deemed unhealthy for sensitive groups (USG). Days which surpass this threshold are known as “exceedance days”. Maryland has seen a significant decrease in the number of $PM_{2.5}$ exceedance days (*See Figure 1*) over the past 15+ years due in large part to the adoption of regulations to reduce emissions of SO_2 and NO_x. In 2020, there were ZERO days which exceeded the EPA health based threshold.

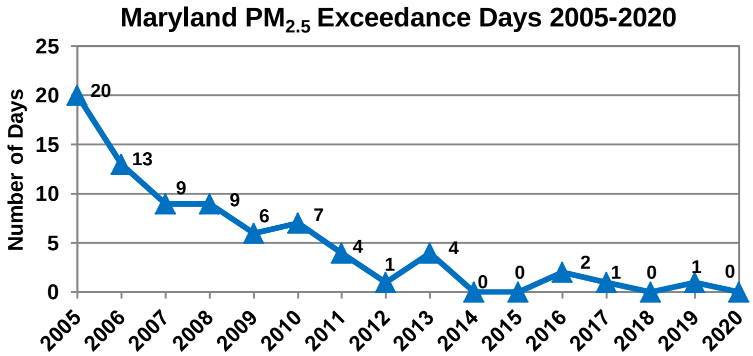

Figure 1: Annual number of days where the AQI surpassed 100 at any $PM_{2.5}$ monitor in Maryland, 2005-2020.

PM2.5 AND COVID-19

2020 was a very unique year for pollutants measured across Maryland and the entire world for that matter. With the global pandemic, COVID-19 forced many folks to limit travel and stay at home. Car traffic in Maryland saw a significant decrease beginning in mid-March and lasting through to the new year. Electricity demand also saw a slight dip over this time frame as well, particularly during the early stages of the pandemic in March, April and May. Electricity Generating Units (EGUs) are a well known source of both NO_x and SO_2. Vehicles also contribute a significant amount of NO_x into our atmosphere. Both of these emissions are precursors to $PM_{2.5}$ pollution. It is difficult to say quantitatively how much reduced emissions from these two source sectors contributed to the low $PM_{2.5}$ concentrations in 2020. What cannot be argued, however, is that their reductions clearly played a role.

SEASONAL HIGHLIGHTS & STATS

2020 marked the fourth year in Maryland’s recorded history to have zero total $PM_{2.5}$ exceedance days. With conditions being so clean the last five plus years, a good alternative to exceedance days is to look at the number of “haze days”. A haze day is defined as when the daily average $PM_{2.5}$ concentration exceeds 25 µg/m^3. On days that fit this criteria, the air is perceptibly hazy (*See Figure 2*). These days are also becoming few and far between, with 2020 only having three. This is tied for the fewest number of haze days for a given year in Maryland’s recorded history.

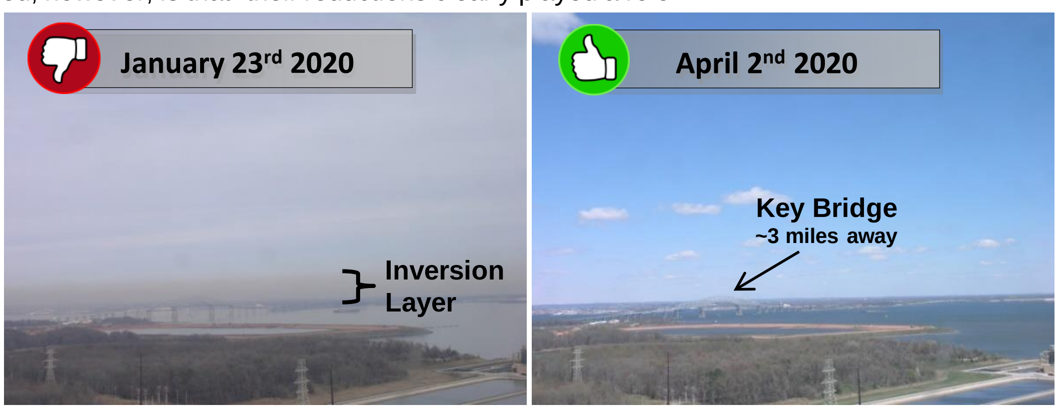

Figure 2: Visual comparison of “haze day”, January 23rd (Left) and a Good Air Quality day, April 2nd. The inversion layer is noted on the left as indicated by the “brownish” color. Key Bridge location and approximate distance is noted on the right.

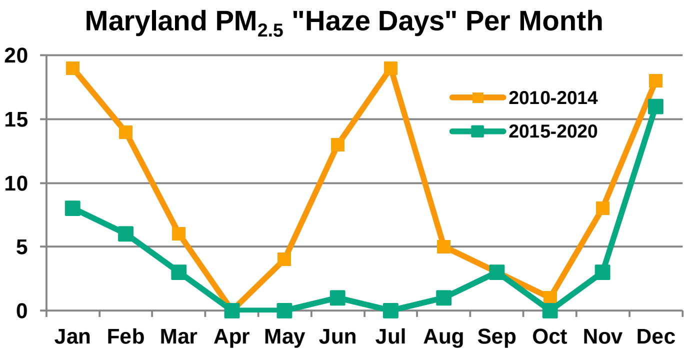

Figure 3: Monthly breakdown of the total number of $PM_{2.5}$ “haze days” for the timeframes of 2010-2014 and 2015-2020 in Maryland

As seen in Figure 3, not only are the total number of haze days decreasing, but the seasonality has shifted as well. Days in winter with relatively high fine particulate concentrations, although rare, can still occur. These events become even more scarce during the summer months. This seasonal shift has been fueled by significant emissions reductions set into place by the Maryland Healthy Air Act. This act required major reductions in air pollutants to be phased in at Maryland power plants starting in 2009 with additional reductions in 2012 and 2013. At its current full implementation, the Healthy Air Act has helped to reduce NO_x emissions by approximately 75 percent and SO_2 emissions by approximately 85 percent from 2002 levels. As the total emissions of NO_x and SO_2 have decreased, the meteorology and chemistry which fuel $PM_{2.5}$ episodes stand out more and help to highlight this seasonal shift.

AQI 0-50 Good	51-100 Moderate	101-150 USG*	151-200 Unhealthy	201-300 Very Unhealthy	301-500 Hazardous

*Unhealthy for Sensitive Groups

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SEASONAL HIGHLIGHTS (cont.)

Meteorologically, both summertime and wintertime $PM_{2.5}$ episodes begin with a prolonged stagnation weather pattern. This is typically characterized by weak winds and a fairly shallow mixed boundary layer. In winter, there are instances when a layer of air aloft is warmer than that at the surface. This vertical temperature profile is known as a surface inversion. When there is an inversion, all pollutants become trapped and concentrated right near the immediate surface. This can clearly be seen in Figure 2 as a light brown haze. Surface inversions in summer can occur, although they do not appear as regularly or as severe. Given the higher noon sun angle, any surface inversions which do develop overnight are typically broken as temperatures climb during the mid-morning hours and in turn $PM_{2.5}$ levels typically drop. During the 2010-2014 time period, when the regional air mass was "dirtier", haze days were still common despite this daytime mixing.

Additionally from a chemistry standpoint, summer time $PM_{2.5}$ events are primarily fueled by SO_2. SO_2 when in the presence of water vapor can grow to form fine particulates. Since there is more water vapor available in the summer, SO_2 is more apt to grow during this time period. However as phases of the Maryland Healthy Air Act were set into place, the SO_2 readily available in the atmosphere became less and less. This in turn led to fewer and fewer days in the summer with elevated $PM_{2.5}$ concentrations. $PM_{2.5}$ exceedance days, and haze days during summer have become heavily reliant on the influence of smoke, whether it be from natural or anthropogenic sources.

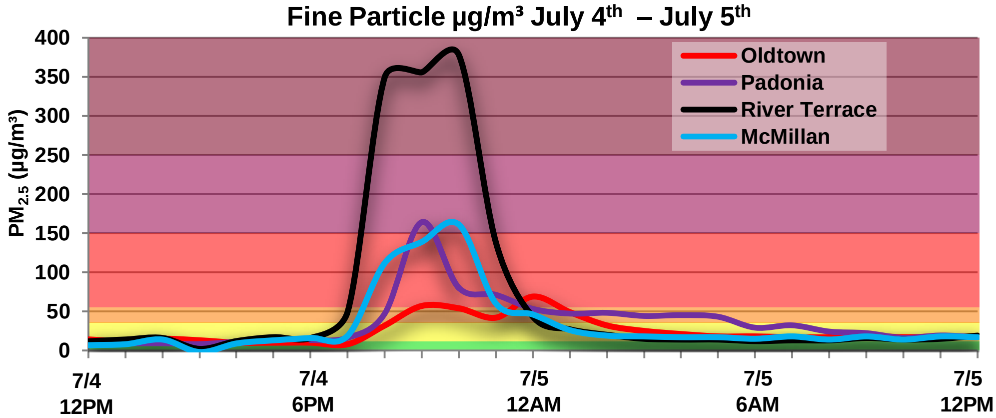

Figure 4: Hourly $PM_{2.5}$ concentrations (µg/m³) between the timeframe of 12PM July 4th and 12PM July 5th. Horizontal coloring matches with appropriate AQI ranges. McMillan and River Terrace are located in the DC area, Oldtown and Padonia are located in the Baltimore area.

FEATURED EPISODE: July 4th and 5th

From our nation's founding, the Fourth of July has been synonymous with fireworks. While many grew up learning that fireworks can be dangerous to the eyes and hands if not handled properly, fireworks also produce dense smoke clouds that are full of fine particles as well as other water-soluble ions and trace metals.

Many large fireworks displays were put on hold in 2020 due to COVID-19 restrictions. However, several large events still took place including Washington DC's (DC) iconic National Mall display. Meteorology during the evening of July 4th was favorable for limited smoke dispersion with weak winds and broad high pressure across the area. As the fireworks began shortly after 9 PM, large spikes in fine particulate concentrations were noted at several DC monitors. As seen in Figure 4, both the River Terrace and McMillan monitors, which are only ~4 miles from the National Mall saw significant spikes in $PM_{2.5}$ concentrations. River Terrace measured three hours in excess of 350 µg/m3! Despite most of the early part of day seeing hourly values in the Good AQI range, this three hour window pushed the 24-hour average $PM_{2.5}$ concentration at River Terrace to 62.29 µg/m³! This resulted in the DC region achieving the Unhealthy AQI category.

Around Baltimore, spikes in $PM_{2.5}$ were not quite as extreme. Oldtown (*located in downtown Baltimore*) commonly sees elevated $PM_{2.5}$ concentrations on July 4th due local individual fireworks displays in the Baltimore area along with the annual fireworks display at the Inner Harbor. COVID-19 restrictions canceled this year's Inner Harbor annual event; however individual fireworks shows did lead to elevated $PM_{2.5}$ concentrations on the evening of July 4th, lingering into the 5th. Daily 24-hour average $PM_{2.5}$ concentrations measured on the 4th and 5th at the Padonia station (*located just north of Baltimore City*) were 24.13 µg/m³ and 24 µg/m³. These values were still below the exceedance day threshold but well above normal levels, particularly during the summer months (*See Figure 5*).

The EPA accounts for the use of fireworks on the Fourth of July and at other cultural events by allowing states to demonstrate that the short-term $PM_{2.5}$ spikes measured on July 4th and 5th were influenced by firework displays and should not be used in determining whether an area has violated compliance of the NAAQS. While the EPA does not regulate fireworks, it does recommend that people who are considered sensitive to fine particles try to limit their outdoor exposure by watching fireworks from upwind or as far away as possible.

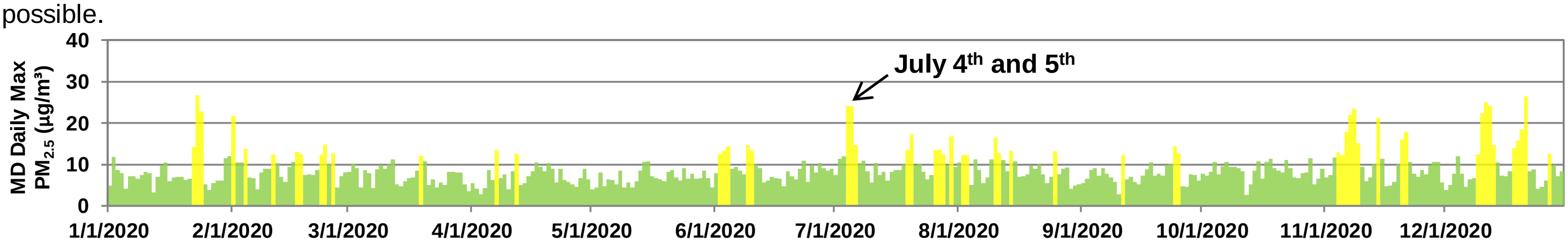

Figure 5: Average maximum daily 24-hour $PM_{2.5}$ (µg/m³) in Maryland from January 1 – December 31, 2020. Bars are color coded by AQI. July 4th and 5th are noted.

AQI 0-50 Good	51-100 Moderate	101-150 USG*	151-200 Unhealthy	201-300 Very Unhealthy	301-500 Hazardous

Unhealthy for Sensitive Groups based on 2015 8-hr ozone NAAQS. Denotes the USG