Comparison of PM 2.5 Measurements in Manhattan and the Bronx: How Higher Levels of PM 2.5 Can Make More People Susceptible to Respiratory Diseases Such as COVID-19

Jose Carlos Serrano
Emily Hollyday
West End Secondary School
New York, New York
United States
1.28.21

Abstract:

The reason behind my studies regarding this subject is due to the shocking high number of COVID cases that were reported in areas such as the Bronx near where I live. The highest cases in the city in some cases were reported in this borough with underrepresented minority groups taking the brunt of this deadly virus. After hearing reports of how in areas such as Hunt's Point or Mott Haven in the Bronx, communities were being affected disproportionately by the virus, I became curious to why this is.

Coincidentally in my Earth Science class, we were beginning work on a project about air quality, and after learning that poor air quality was linked to this spike in COVID cases I knew I had to make this my project. Even though sometimes, I was met with drawbacks in terms of finalizing the main focus of my project, I decided that it would only make sense to focus on how the Bronx still has higher numbers of PM 2.5 than Manhattan per say, even when during COVID-19, PM 2.5 rates went significantly down. To pursue my project, I used advanced softwares such as PurpleAir to measure air quality, and the GLOBE Observer App to provide in-depth evidence, and photos to back up my claim. After days of recording data, making conclusions on it, and more, I decided that I could go further with this project; that this topic is important and relevant and should be addressed. This is why I took the opportunity to submit to the Science Symposium, to share what I learned and to help me get to the next steps of being able to help these underrepresented communities.

Table of Contents

Introduction:

Years of Poor Air Quality in locations such as the Bronx have weakened people's respiratory systems leading to higher rates of asthma, sickness, and a high number of COVID cases in these areas. The issue many don't notice is that the Bronx has one of the highest levels of pollution in the city due to factories, high exhaust areas such as major highways, and the unfortunate neglect for the pollution that threatens the health of countless citizens. Many companies, especially delivery companies such as Fresh Direct have their headquarters situated in the Bronx. When going out to deliver, these trucks all must return to the main warehouse in the Bronx; all these trucks put out exhaust. The combustion of fuels released by delivery trucks, garbage disposal, and other cars all release toxic air into minority represented neighborhoods. In addition to pollution created by vehicles and transportation, the South Bronx in particular is situated underneath three major highways - the Major Deegan, the Cross Bronx Expressways, and the Bruckner. Scientifically, severe exposure to pollutants results in damage to one's respiratory system. COVID-19 is a virus that specifically affects one's respiratory system, greatly emphasizing the fact that in the fight against this unprecedented pandemic, citizens in the Bronx and similarly polluted areas have a disadvantage. Medical scientists from the World Health Organization have even tackled the subject. Dr. Maria Neira of the WHO mentions, "If you realize that exposure to air pollution will increase the risk of diseases of the respiratory system – and the COVID-19 is mainly a disease of the respiratory system – you will realize that we are increasing the susceptibility, the vulnerability of people who are exposed to air pollution." I myself, a resident of the South Bronx have noticed these shocking revelations. When using softwares such as NASA's GLOBE Protocol and PurpleAir, I noticed that the pollution rates in the Bronx are much higher than in locations such as Manhattan and other boroughs. One might be curious to why pollution is so high in certain parts of the Bronx. One attribute is the unfortunate stigma of systemic racism. Robert Moses, credited with being a prominent conservationist and having a beach named after him, was actually a racist. A recent informative zoom meeting with the Bronx Art Deco Institution described Moses as "Good Robert" and "Bad Robert". The good being the conservation and environmental efforts he made, advocating for parks land and emphasizing the importance of them. The bad being the fact that he tried to single out certain communities in the Bronx. At the time, Moses was one of the richest men in the country and decided to build the three highways mentioned before, the Major Deegan, the Cross Bronx Expressways, and the Bruckner. Hopefully as more people discover the disturbing truth of what's facing these underrepresented areas, there will be more advocates for this issue and following that, some greatly needed change.

Research Question and Hypothesis:

Research Question: How have years of pollution in poorer places raised the number of COVID cases in these areas?

Hypothesis: Years of pollution in poorer areas have weakened people's immune system, hence the huge number of COVID cases in these districts.

## Research Methods, Materials, and Study Site:

Materials:
- Paper
- Pens and Pencils
- Windows Computer
- PurpleAir website
- GLOBE Observer App
- Google Docs for documenting research
- Google Slides for my presentation
- Google Sheets for documentation of data.

Methods:
1. Open computer and go to PurpleAir.com
2. From there, click only on outside air sensors for accuracy, and then search for locations in the range in which my project is focusing on. In my case, It would be the Bronx and Manhattan.
3. Record Air Quality data by taking screenshots of the two locations on PurpleAir.
4. Go outside after, to collect outside data using the GLOBE Observer App.
5. Take photos with the app and submit in the app to check for any satellite matches.
6. Come back home and document my observations and data using google docs and sheets.
7. Using google sheets, compose my collected data into a graph.
8. Add any additional data to google docs and sheets and repeat the next day.

Study Site:
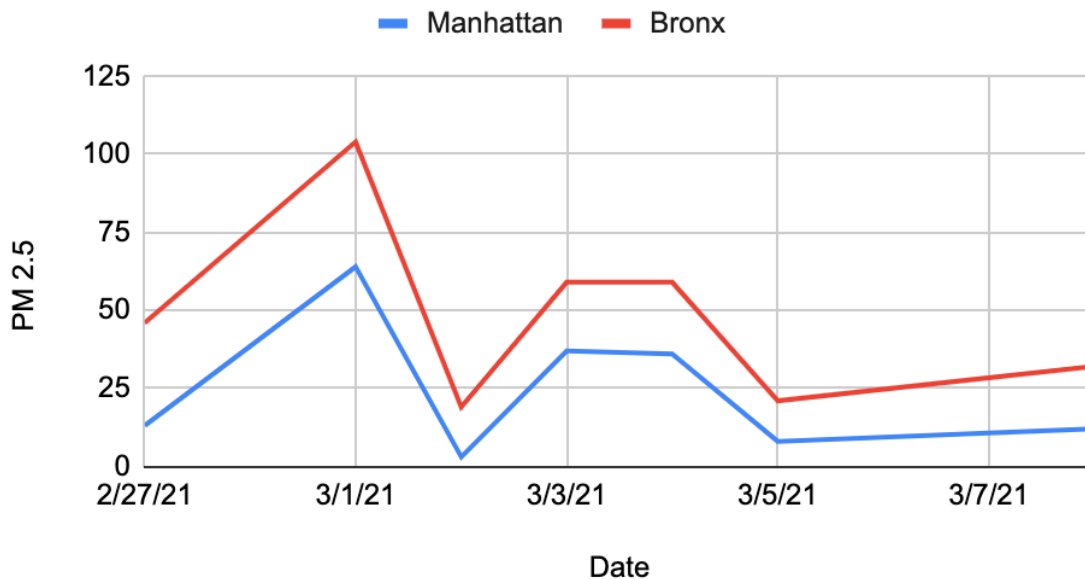Manhattan - directly across from Roosevelt Island.
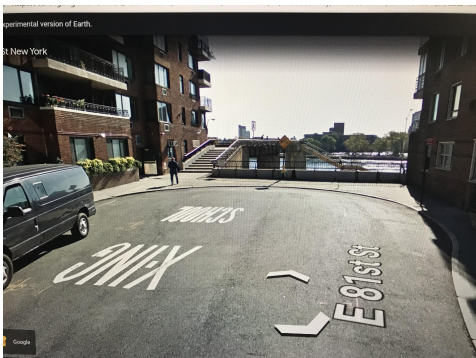
The South Bronx, Near Pelham Manor

Results:

Figure 1. This graph was created using my own personal data from PurpleAir. It covers six days and I chose a shorter time period to show how in such a short time, PM 2.5 is at high levels and very prevalent. 3/1/21 was one of the most disturbing. While both places were polluted, the Bronx had 50% more pollution than

Manhattan. One might say that not all days are like this, etc. but constant exposure to such polluted air does result in people's lungs and respiratory system getting permanently damaged.
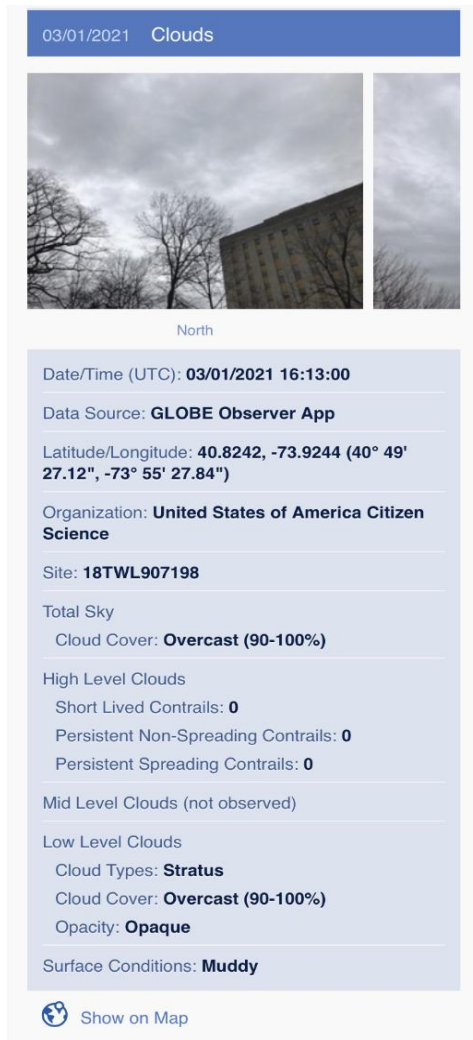
Figure 2. Paragraph about your observations from this day and how they relate to your data on the graph above. On 3/1/21, the PM 2.5 in the Bronx was 104. The sky appeared to be dark, grey, and with noticeable overcast. It's days like this that emphasize the Bronx's high rates of pollution. I collected this data in a park near my house using the GLOBE Protocol. The chart above was from my own observations and collected data with this day being represented in the huge spike in PM 2.5 at the beginning of the graph. The data collects six days of data, a smaller range, collected in the South Bronx.

Figure 3. Cloud observations from 3/5/21

Satellite	GEO	Terra	Your Observation
Universal Date/Time 2021-03-05	16:33	16:32	16:19
Latitude Range Longitude Range	40.51 to 41.15 -74.24 to -73.6	40.46 to 41.26 -74.25 to -73.45	**Latitude 40.825200** **Longitude -73.923700**
Total Cloud Cover	No Clouds	Isolated 12.43%	**No Clouds Observed**
HIGH Cloud Cover / Cloud Altitude / Cloud Phase / Cloud Opacity	No Clouds	No Clouds	No Clouds Observed
MID Cloud Cover / Cloud Altitude / Cloud Phase / Cloud Opacity	No Clouds	No Clouds	No Clouds Observed
LOW Cloud Cover / Cloud Altitude / Cloud Phase / Cloud Opacity	No Clouds	Isolated 12.43% 0.16 (km) Mixed 273.38 (K) Transparent	No Clouds Observed
Corresponding NASA Satellite Images. Click to view image --->	*GOES-16* Visible Infrared GEO Tutorial	*MODIS* Rapid Response Worldview	Sky Visibility : Clear Sky Color : Blue

Figure 4. Today however, I noticed the sky was actually clear and was blue. Much different than 3/1/21, this day emphasizes how the pollution rates can as simply spike up as they do down. How these high level days of pollution can be unpredictable in some cases. The thing is, that even though the sky was clear, there were still significant levels of PM 2.5 compared to Manhattan.

The data shown below are the GLOBE satellite matches for this day's data. The satellites themselves saw similar if not exactly the same findings that I observed myself. Curiously, as mentioned, the clouds were clear, yet there were still significant levels of pollution. This can be a explanation supporting the fact that pollution can't necessarily be identified by simply looking at the sky; more scientific and technological practices must be in effect instead.

Hourly PM 2.5 Levels in the Bronx and at West End Secondary School from 2/16/21-2/24
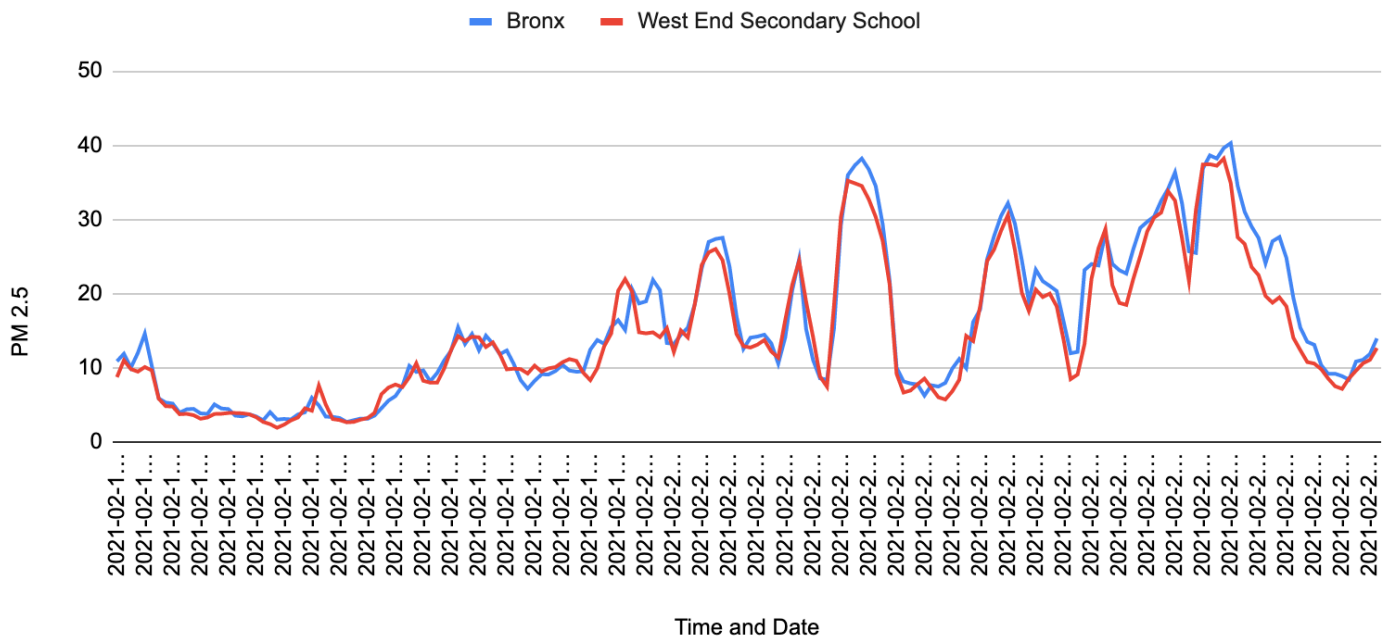
Figure 5. The graph to the right was received through PurpleAir's previous PM 2.5 records ranging from 2/16/21 to 2/24/21. The data was collected on an hourly basis throughout these days. The red line represents my high school, West End Secondary, which is in Manhattan. The Blue line of data represents the Bronx. Note how the blue line continuously succeeds that of the red one consecutively.

Discussion:

      The results I collected show us many things about PM 2.5 pollution in the Bronx and more. The data I collected via PurpleAir emphasize the fact that the Bronx does have high levels of pollution and in some cases, suffers disproportionately than other locations in the city. For my experiment, I focused on the comparison between Manhattan and the Bronx. The PurpleAir website showed shocking results: in some cases the Bronx had levels of PM 2.5 that were **50%** higher than the levels in Manhattan. As mentioned, 3/1/21 was the most polluted and surprising with the South Bronx suffering from a level of 104 PM 2.5 while Manhattan only experienced levels of 64 PM 2.5. My research was eye-opening and at the same time, disturbing as well. It was very sad to see how pollution rates were so high in these areas because I understand that high levels of pollution can lead to certain health risks. After using PurpleAir, I turned to the GLOBE Observer App. The application allowed me to take actual photos of the sky and provide visual evidence for my project. I took photos using GLOBE and found a few satellite matches as well. I collected GLOBE data the same days I collected PurpleAir data to provide the accurate PM 2.5 rates and a photo for visualization with it. Using these softwares, I was able to conclude that the Bronx does suffer from high rates of pollution definitively by comparing its pollution rates to Manhattan. The smaller graph in which I put all my data shows this over a short period of time, six days to be precise to show how poor pollution is, near around a week. The bigger graph was downloaded from PurpleAir, an hourly count of pollution rates, each day, for eight days. I used this graph to show PM 2.5 rates over a long period of time. Both graphs collectively show the same thing: the Bronx had mostly higher PM 2.5 rates than Manhattan. But the question is, what do these high levels of PM 2.5 show us? Doctors suggest that the reason that so many Bronx residents have underlying health conditions such as respiratory diseases can be credited to pollution such as PM 2.5. PIX II's *Environmental racism in the Bronx: Why the asthma rate is so high in the borough* by Jay Dow, addresses the situation. The article mentions, "Why? If you take out your phone, find the South Bronx in your maps app, a search for "Transfer Station" produces markers for almost a dozen facilities.the article then goes on to mentioning, "Urban planning projects, led several decades ago by the late master planner Robert Moses, ultimately encircled the South Bronx inside a ring of major highways: the Cross Bronx Expressway to the north, the Major Deegan Expressway to the west and the Sheridan Expressway to the east. The result? Residents are forced to live in, around, and under a haze of transportation generated air pollution." These quotes emphasize the fact that due to racism and poor public planning, the South Bronx has become a dumping ground for polluted air, to the detriment of the residents that live there. Insider News provides a graph regarding the situation.

The Complicated History Between Robert Moses and the Bronx:

While many may see Robert Moses as a Pioneer for parks, natural landscape, and more, at heart he was really a racist. While his conservation methods and advocacy are true, they were fueled by his hatred for African Americans and Latinos. In locations in the Bronx, he purposely built three highways strategically around the South Bronx, dumping tons of polluted air such as PM 2.5 from car exhaust into these minority communities. It's because of acts of racism like this that also push the Bronx into having one of the highest levels of pollution in the city. Many delivery depots keep their factories in the Bronx while catering to locations such as Manhattan. At the same time, these delivery services won't deliver or be present in certain areas as they deemed them "dangerous". Most of these "dangerous" areas are primarily made up of African Americans and Latinos.

What We Can Do With This Information:

What we can do now, learning that the Bronx has higher PM 2.5 rates than Manhattan, is how to make a difference. I do believe that advocating for change such as PM 2.5 regulations, more care for implementing natural resources, and how regular exposure to PM 2.5 can lead to health risks, especially in a pandemic that attacks one's respiratory systems. Now knowing the shocking truth regarding historic racism, years in the making, and more has resulted in atrociously high PM 2.5 rates in the Bronx, we now know what we must advocate for. That we must understand that communities are suffering, people have severe health problems, and many of these issues stem from PM 2.5 and other pollutants. We can reach out to organizations that specialize in reducing PM 2.5 and pollution in the city as well.

Badge Narratives:

These Are the Following Badges I Would Like to Apply For:

Make an Impact Badge: For my project, one of the badges I focused on was the "Make an Impact Badge" to emphasize the importance and fact that normal people in their communities can make a difference in their neighborhoods. To put this badge into effect, I invited a group of middle school students from Syracuse to listen to my project idea. I introduced the students to the Make an Impact badge and how accessible it was to become an advocate for protecting our environment and planet.

STEM Professional Badge: As mentioned previously, I worked on this project for a while and tried to present it in a creative and professional fashion. To seek further feedback, I got constructive criticism and ideas from NASA Scientists Angela Rizzi and Dr. Margaret Pippen. They contributed to helping me reinvent certain parts of my project and narrowing it down directly to how years of pollution in poorer areas have resulted in a higher number of COVID cases there.

Conclusion:

From my studies, I concluded that poorer areas have been at a disadvantage to fighting COVID due unregulated levels of pollution. Due to historic and present racial stigmas, these communities have been exposed to years of pollution and currently today, still suffer. COVID-19 was an eye-opener to everyone, not just about how pollution is such an important issue and needs to be addressed but also exposed the result of neglect to underrepresented and minority communities. GLOBE and PurpleAir have allowed me to pursue my research by providing helpful and useful options and resources. I can conclude that one of the main reasons that COVID-19 rates are so high in poorer areas is due to neglect and pollution unfortunately.

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