DETERMINING PARTICULATE MATTER CONCENTRATIONS WITHIN A NEW YORK CITY PUBLIC SCHOOL

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Harlem, NY

2009

Abstract

Particulate Matter (PM) is a generic term for a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplets or solids) over a wide range of sizes. With Harlem being one of the areas in the United States, with the highest PM concentrations, this project sought to determine which locality of a New York City public school has the highest PM concentration. The experiment was conducted by moving a PM sensor from one locality to the next. At the end of measuring, a staircase, which is located on the south end of the building, had the highest levels of concentrations, with 20.96 ug/m3 without people in the area and 21.98 ug/m3 with people in the area. These levels are in violation of the yearly PM level exposure which are 15 ug/m3 set by the EPA. However, the average Particulate Matter level of the other localities (i.e. classrooms) was 6.65 ug/m3 without people and 6.07 ug/m3 with people.

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Introduction

According a 2009 NATA report, the chances of getting cancer living in Harlem are over 100 out of a million. This is the highest in the whole island of Manhattan. Particulate Matter (PM) is a generic term for a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplets or solids) over a wide range of sizes (EPA, 2009). There are many breathing problems that people have because of what people breathe (i.e. Dust from a construction site, second hand smoke, exhaust from cars, etc) (EPA,2009). Over the last few decades, people have been more concerned about their health and about the world, that we live in. Being concerned about the world also includes showing concern for the air that we breathe. Many programs today are trying to raise awareness about the air quality such as, WE ACT and Harlem River Park Task Force. Because of these programs, people now know more about their communities and know more about the things that harm them, and can figure solutions to fix them

Levels tend to be higher indoors than outdoors. The EPA (2007) defines “inhalable coarse particles” as those ranging in size from 2.5 to 10 micrometers, and “fine particles” as those smaller than 2.5 micrometers. In 1997, the first regulations for PM2.5 were put in place after research proved that smaller particles were more detrimental to health. Knowing that Harlem has high levels of P.M. in the nation, conducting P.M. research in a Harlem school will be an important project. In this project, I will be sampling P.M. in a High School, and in different rooms. The question proposed was where in a New York City Public School is the PM concentration the greatest.

Project Design Chart

Scientific Problem
Which locality in the Public School Building has the highest P.M. concentration?
Hypothesis
Particulate Matter levels will exceed the E.P.A.'s yearly average of 15 ug/m3
Objectives
Determine Particulate matter concentrations from different classrooms
Compare P.M. Levels in different localities
Determining sources of PM and prevailing winds
Independent Variable
The different localities
Dependent Variable
P.M. concentrations
Constants
Time in a locality
Assumptions
P.M. concentrations does not change within time experimentation
Sample time is sufficient
P.M. sensor is running correctly
Limitations
Materials
Amount of time that is spent in one locality

Background Information

According to the EPA (2009) Particulate Matter is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. Particulate Matter has been known to cause health issues such as cancer, and upper respiratory problems. In 1997, the first regulations for PM2.5 were put into place after research proved that smaller particles were more detrimental to health (Warbelow, 2007). Currently, the EPA regards particulate matter as one of six criteria pollutants regulated by the National Ambient Air Quality Standards (NAAQS) under the Clean Air Act (2007).

According to Medical News Today (2004), children exposed to urban air pollution before birth, were more likely to have a lower IQ than less exposed children. A review of the existing literature indicates that sufficient research has been done to prove the importance of monitoring particulate levels, especially at the 2.5-micrometer level, in relation to health outcomes. Another PM size relevant is PM 10 Major sources include: motor vehicles, wood burning stoves, fireplaces, dust from construction, landfills, and agriculture, wildfires and brush/waste burning, industrial sources, windblown dust from open lands (Particulate Matter Air Pollution, 2009).

The area in which the New York City Public School is surrounded has an enormous amount of particulate matter, levels that exceed the yearly limit of 15 ug/m3 (EPA, 2009). The risk of developing cancer, in the school's surrounding area within a 5-block radius in any direction is higher than one hundred in a million (EPA, 2009). It is a relatively high rate as the number is at least three times higher than the national average of 36 in a million (Cappiello 2009). The air is contaminated enough to cause several cancers and respiratory diseases.

In a new study done by Dr. Perera (2009) of the Mailman School of Public Health at Columbia University, it was determined that children born to mothers that had increased exposure to air pollution during pregnancy were likely to have lower IQ's than those not exposed to air pollution. The IQ's of children roughly the age of five were measured and compared. The children that were exposed to polycyclic aromatic hydrocarbons or PAH's, had an IQ less than 4.67 points on average. Particulate Matter in the form of PAH, is byproducts of cars or other organic sources.

The PM that the children in the South Bronx, North Harlem, and Washington Heights are exposed to while their mothers are in labor, is alarmingly above the national average (NATA). These numbers are alarming, as the air quality in Harlem is one of the worst in the nation and despite the fact that the air is getting better, these conditions still exist and hinder the development of children.

Schools and PM are huge issues that seem to never be explicitly addressed. The localities in which children are learning it on a daily basis have not been sufficiently studied. Schools are place where young people spend one-fourth to a third of their day, 5 times a week. If the quality of air at a school is not on par with standards then the children are subject to respiratory diseases and or cancer. New York City in particular has very diverse social and economic status. Areas of Harlem suffers from and are subject to high levels of PM, while better social economic areas such as the Lower East Side, or Upper West Side may have better PM data according to EPA.

The EPA is required by the Clean Air Act to carry out assessments of the National Ambient Air Quality Standards (NAAQS) for the six criteria pollutants, including PM, every 5 years (GAO 2006). According to the GAO (2006), during these assessments, the EPA looks to determine whether the present principles are satisfactory to protect the health of the public. The

National Academies' 2002 report scrutinized how the EPA determined the health benefits of its projected air regulations, and highlighted the need for EPA to account for uncertainties (GAO 2006). The EPA has begun to investigate what changes should be made to the standards they set for air quality. In 2006, two thirds of the National Academies suggested revision for the standards (GAO 2006). These changes include more rigorous assessment of the data being recorded by the EPA. In addition, the Governmental Accountability Office (2006) stated that the National Academies suggested a more detailed analysis of how the PM leads directly to respiratory diseases. This is a prime example of one of the many changes recommended and taken into account; however, during this time (2006) the EPA still had not addressed "relative toxicity of components of particulate matter, " which in laymen's terms means, the EPA still has not found all of the possible harm that PM can inflict (GAO 2006).

According to a study done by Harlem Hospital in 2003, one in four children in Central Harlem had asthma (Perez-Pena 2003). This was double what researches expected and one of the highest rates ever documented at the time (Perez-Pena, 2003). The study supported the theory that asthma was on the rise nationally, but especially in poor urban neighborhoods. Perez-Pena (2003) stated that The Centers for Disease Control and Prevention estimated asthma rates to be about 6 percent nationally at the time; there was speculation that New York City's rate was much higher, and the rate of the South Bronx and Harlem reached the high teens and nearly 20 percent. As Perez – Pena stated, "Environmental factors like pollen, dust, animal dander, air pollution and cold air also contribute to development of the disease and can lead to attacks" (2003). It was also alarming that 25 percent of the children diagnosed had no prior knowledge that they had asthma. This can be attributed to the parents not taking the initiative to get their children checked out, and doctors being reluctant to diagnose children with the disease (Perez-Pena, 2003).

PM is something that is universally affecting people across the globe. In a 2001 study done in Ottawa Canada, researchers found how PM Bin 10 was affecting the amount of Cytokine in cells (Fujii et al., 2001). According to Fuji (et al., 2001) Cytokine is used by the body to regulate immunity (Decker, 2006). "Residents of communities exposed to high compared with low levels of air pollution have faster rates of decline in lung function, more chronic respiratory and cardiovascular disease" (Pope et al., 1995). The study found that PM Bin 10 was found at a high rate in several comminutes across Ottawa Canada. Since these high levels of PM Bin 10 existed, the amount of Cytokine produced, has decreased. Thus, these people in the area of Ottawa Canada were more susceptible to diseases such as leukemia.

When children are young and exposed to high levels of PM it may have an everlasting impact. Researchers studied children in Menorca, Spain to see how exposure to household gasses affected them (Morales et al., 2009). The children were tested to see if they had attention-hyperactivity behaviors and basic functioning. According to Morales (et al., 2009), "Use of gas appliances was inversely associated with cognitive outcomes." He adds, "Early-life exposure to air pollution from indoor gas appliances may be negatively associated with neuropsychological development through the first 4 years of life, particularly among genetically susceptible children." PM is on the rise globally. Lung cancer and asthma are being promoted in parts of Massachusetts due to high instances of disease PM being produced by trucks on neighboring highways (McEntee, 2009).

Locality

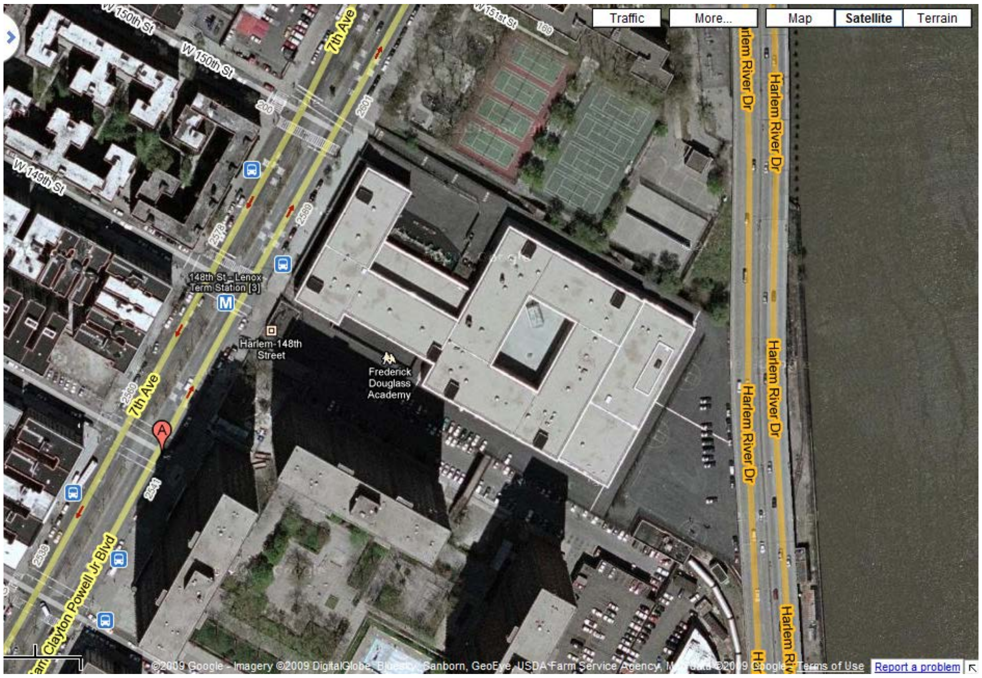

Figure 1- The Frederick Douglass Academy. This Experiment was conducted at the Frederick Douglass Academy. 2581 Adam Clayton Powell Jr. Blvd New York NY 10039. The following is a list of the localities. Room 310 room 312, room 330, room 338, room 339, staircase I, room 357, room 363, staircase D, and room 347. (Refer to figure five for more details)

Materials

Materials	Quality	Description
MET one Aero 212(P.M. sensor), Texas	1	Used to collect Particulate Matter
Cart	1	Used to move the materials around
Stopwatch	1	Used to keep count of time
Universal Battery (Cart Battery) Leesburg, Florida	1	Used to power the P.M. sensor
Dell Latitude (India)	1	Used to hold the data that is collect my the Sensor
HyperTerminal(program)	1	The program used to display the data from the Pm sensor
Camera	1	To take pictures of the set- up
Microsoft Excel	1	To make graphs
Air Cable (Bluetooth device) San Jose, California	1	To collect data from the PM sensor
Locality Chart	1	To record what time (From the sensor that is displayed by HyperTerminal) and match it with the locality that you are taking the data.
Video Camera	1	To record procedures
Volt meter	1	Used to find out the power level of the car battery
Pencil	1	To write
Air Cable (Bluetooth receiver) San Jose, California	1	To connect to the computer, so the data can be sent from the P.M. sensor to the computer so that data can be displayed on HyperTerminal
PM Sensor Wire Alligator clips	1	Used to power the P.M. sensor while using a Car Battery
TI- 84 Graphing Calculator	1	To create box plots
Weather Bug Station	1	Acquire wind data
Google Earth (program)	1	To acquire maps

Procedures

Steps for Obtaining PM data

1. Connect PM sensor with the computer to turn it on via Bluetooth and HyperTerminal
2. Place sensor on the cart and connect to battery
3. Make sure the sensor is running and connected to HyperTerminal
4. Go to each locality
5. Take readings for a minute and record what time the readings started
6. After a minute has passed, tell assistants to walk around the locality. Record what time they have entered
7. When finished, move to next locality and record time of exit. Recording time is important in order to know at what time a room was entered and what time the room was exited

Steps for setting up Bluetooth.

1. Hook up sensor to Bluetooth device.
2. Plug in the air filter and make sure the voltmeter works.
3. Open up control panel, then net work connections, then blue tooth device, and click on AIRserial3x06723.
4. Look to see what COM part it was assigned.
5. Open Hypo Terminal program.
6. Name the connection.
7. Select the COM port it was assigned.
8. Press ESC until arrows appear.
9. Once the arrows appear press H.

10. Press T and setup the time interval.

11. Press S and the device would start collecting data according to the time interval.

12. Press Q to stop and copy the data.

13. Open notepad.

14. Paste the data you copied on notepad and save it under a file.

15. Open up Microsoft Excel.

16. Click Data on the tool bar and click import external data.

17. Click import data and click the file you saved.

18. Select Delimited, click next, select comma, click next, and click finish.

19. Save data file.

Converting counts to concentrations

The Aero 212 (the PM sensor that was used) will give readings in counts for that one Bin for a certain period. For example, if readings were taken every 5 seconds, then the sensor will take in air, and at the end of 5 seconds, it will tell how many particles were counted that time. Does not matter how often readings are taken, to acquire a litter of air, the machine must be on for a minute. If readings are being taken every 30 seconds, then that means within those 30 seconds, only half a liter of air was sampled. To carry out the conversion of counts to concentrations, the formula of D= M/V will be used. The D will be 2,000Kg/ M^3, where this is an assumption. To change the Density from 2,000Kg/ M^3 to units that are in centimeters, the decimal place must move over 3 times. (2,000,000 ug/ cm3)

To carry out this equation, we must assume that the particles are spheres. Seeing how the sizes of the particulates are 2 microns in diameter, 1 micron will be the radius. Let us say for example on average, 289 Bin 2 particles on average were found for 30 seconds for the readings.

289 * 2= 578. In one min, there were 578 particles in a liter of air. Seeing how the radius of the particle is 1, well use the formula of a sphere. 4/3(π) r^3. When r= 1, the volume will be 4.2. 578 * 4.2= 2427.6 um^3. Then multiply this by 1.0* 10^12 cm3, and 2.43*10^ -9 cm3. 2.43*10^ -9 cm3 is the mass. To find the volume, multiply 2.43*10^ -9 cm3 * 2,000,000 ug/ cm3 to get it. The mass of the Bin 2 particulate is .00486ug. The find the concentration:

(e.g. 1) $[\ \ ] = \frac{.00486ug}{Liter} \frac{(.5L)}{(1m3)} = 9.72$ ug/ m3

In this example, the Particulate Matter concentration is 9.72 ug/ m3. These steps were taken for all of my other data. This meter using samples a Liter of air per minute, but after testing the meter, the flow rate was only 500 mL, instead of 1 Liter doubling original concentrations that were calculated.

Making Box Plots

Box Plots are used to show the spread of data. By using box plots, people looking at the data will be able to see how spread out the data is for one room, compared to the other rooms. Steps to make Box plots:

1. Take all points and place them in numerical order
2. Find the median, (If there are even numbers, take the middle two, and find the mean)
3. Looking at the lower portion of the data, find the median that will be Q1. Do the same for the upper half and that would be Q3.
4. The smallest number and largest number will stand-alone as a point and Q1, the median, and Q3, will be in a box.

Steps to make Box plots with a TI- 84 calculator.

1. Press the “Stat” key, and press edit (press “1”)
2. In the “L1” column insert all values
3. Press second and mode (quit) and you will return to the home screen
4. Press stat again and move once to right and hit “1-var stats”
5. 1-Var Stats will appear on the home screen press the comma button and the “2nd” and “1” (L1) hit enter. Results will appear.

Observations and Results

Many things were discovered in this project. All of the localities measured except for one were below the yearly exposure rate (see figure 3). On average, when a locality was empty P.M. concentrations were 8.08 ug/m3 compared to a locality being occupied, 7.66 ug/m3 (Figure 2) By using confidence intervals it was determined that having people in a locality as opposed to having that locality empty was not significant (Figure 4) Box plots were used to show spread of the data (Figure 3). Staircase D had the highest levels of PM concentrations out of all the localities. This was the only locality that was in violation of the EPA's standards. The map of the school shows the localities on the eastside of the school had some of the lowest PM concentrations (Figure 5). Immediately on the east side of the building, there is a highway, and 5 blocks east of that highway is a major highway that many trucks drive on. It was believed that PM concentrations would have been higher on that side of the building because winds prevailed east southeast.

Graphs and Images

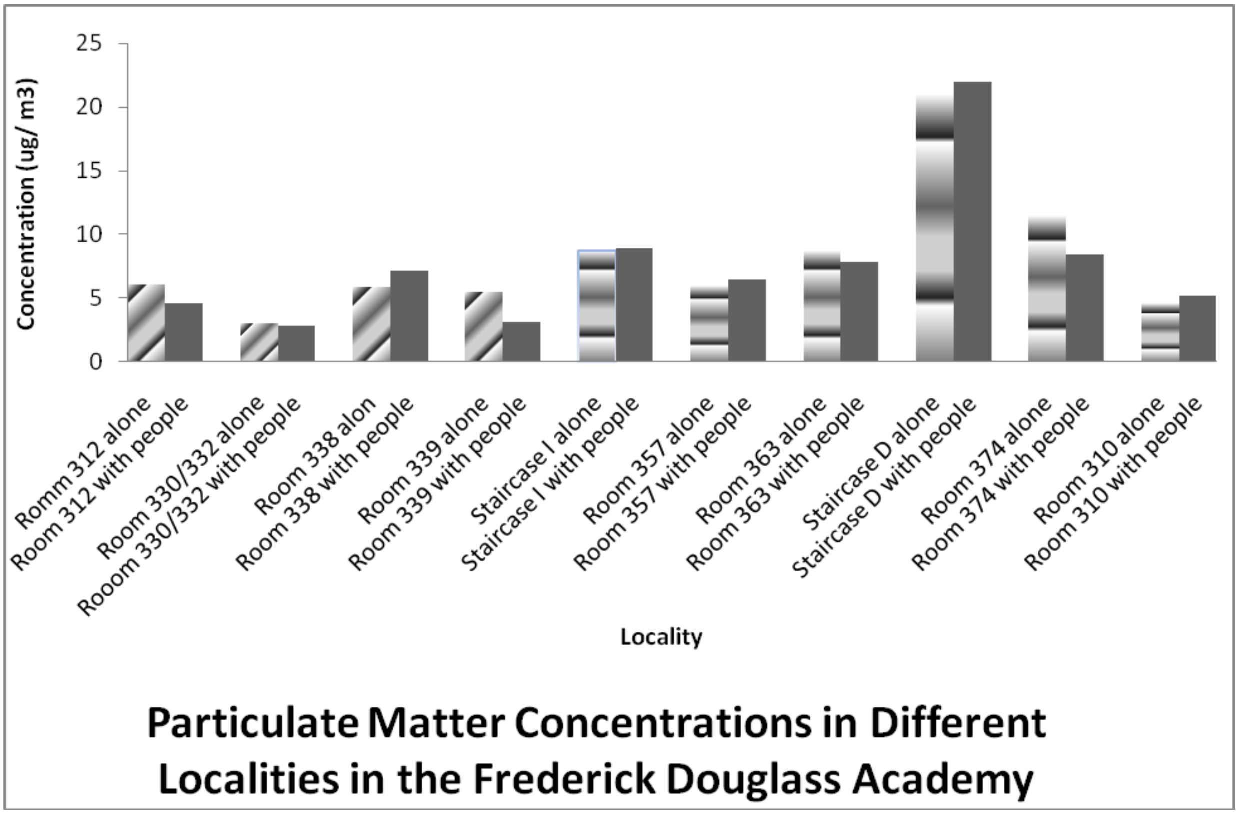

Figure 2 - The graph above displays different concentrations in the different localities in the Frederick Douglass Academy. For the most part, there were not any large differences in data readings when there were people in a locality compared to people not being in a locality

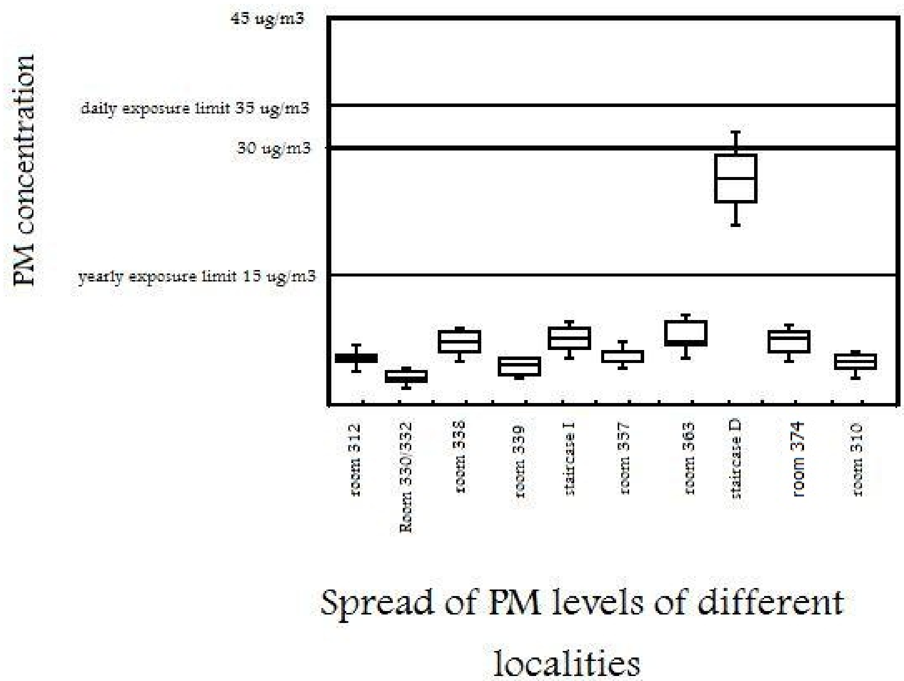

Figure 3 - Above is a set of box plots that describes the data. Box plots are used to show spread. These box plots are only representing the data collected while people were in the localities. There were no mathematical outliers found. It is believed that every data point was reliable and that the machine was working properly. There were not any spikes in the data. The one outlying box plot is the data from the staircase. Its minimum value is higher than the highest value of any other box plot

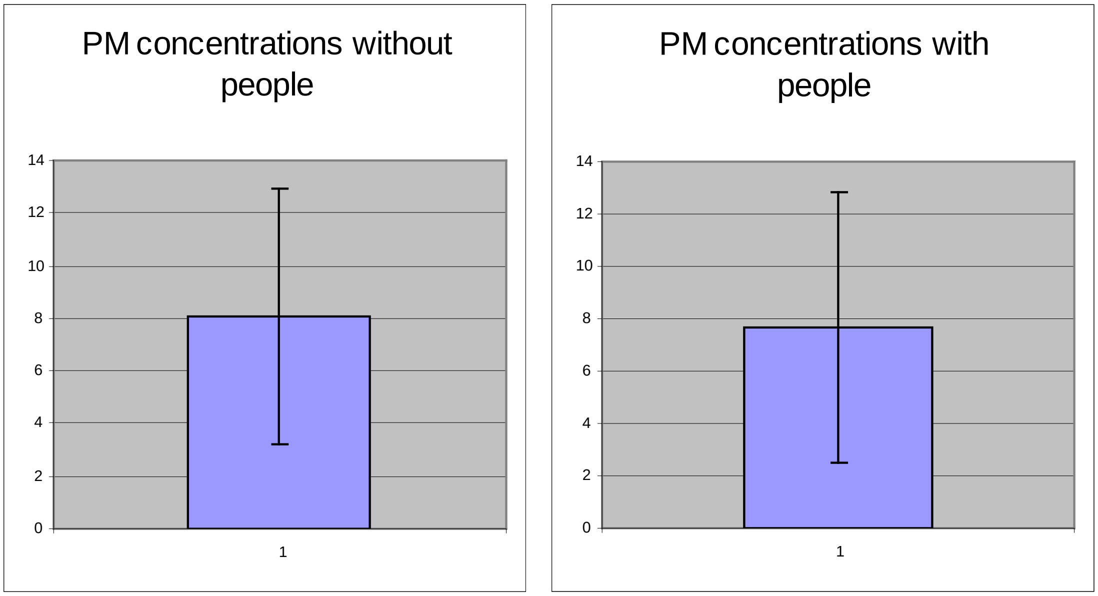

Figure 4 - The above graph shows an average level of concentrations with and withoug people in a locality. The data demonstrates when there are less people in an area, PM concentrations are greater compared to when a loaclity is empty. Y Error bar test are conducted when two sets of data are compared by using bar graphs. One standard deviation will be looked at for each bar. If each of the means (which are represented by the bars) are within a standard deviation of the other bar graph, which means there isnt a signficgant difference between the two sets of data.

Frederick Douglass Academy Third Floor

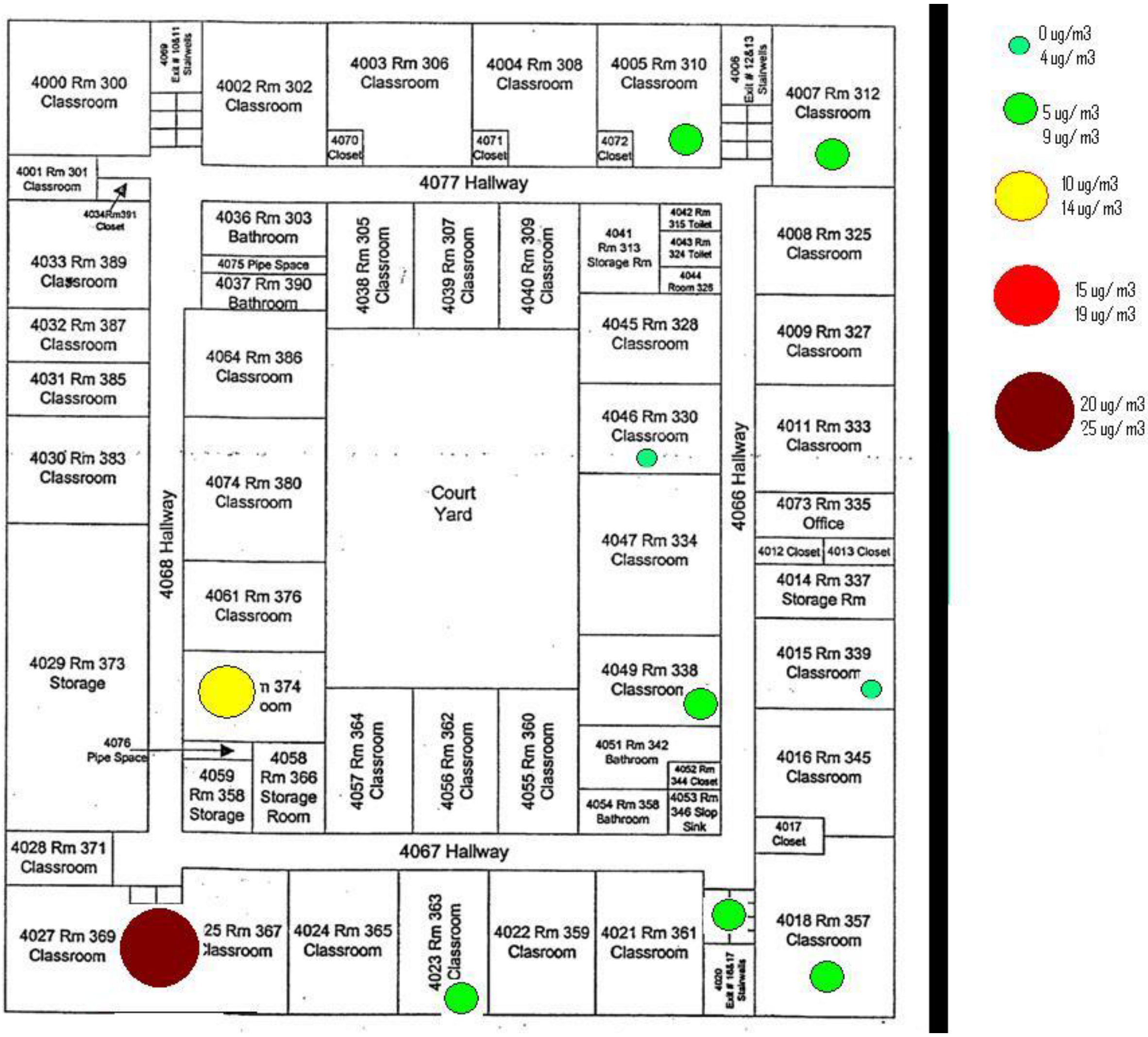

Figure 5 - The above image is a bird's eyes view of the third floor of the Frederick Douglass Academy. Incorporated in this photo, are particulate matter levels in different localities of the school.

Analysis of Results

The hypothesis of P.M. levels will exceed E.P.A. standards was proven incorrect. The mean PM level with people in a locality is 6.65ug/m3 and without people is 6.07 ug/m^3 which were below EPA standards of 15 ug/m3. The only locality that exceed EPA standards was the staircase with PM levels of 20.96ug/m^3.

Particle Matter levels were higher in the staircase located in the southwestern part of the building for many possible reasons. One possibility is that that staircase is the main entrance to the school building and remains open more than any other doors; another possibility is during the time of experimentation there has been a great deal of construction done on the building (i.e. building elevators and repairs on the roof). Lastly, after every lunch period (55 minutes in length) there are about 400 students using that staircase simultaneously. The data collected in that locality demonstrates particulate matter levels increase when people were present (Figure 2). Furthermore, winds in the area of this New York City Public School will usually prevail from the southwest (Ambient Weather, 2009). Using information from the Frederick Douglass Academy's weather station, we were able to determine regional wind patterns. Three days before and a day before experimentation, winds prevailed from the southwest as expected. Located south and west of FDA are waste treatment plants. There recently was a bus depot knocked down, which was located south from the school (Figure 8). Even though the cardinal directions of the source of the wind, and the positioning of the bus depot were different, the construction of a bus depot was only 3 blocks away. It is a good assumption that the bus depot had an important role of increasing particulate matter level readings because of the wind patterns. It is also assumed that particulates from the bus depot were still in FDA at the time of experimentation. On the day of experimentation there were east-southeastern winds that came from the Bronx where there are waste treatment plants located at Hunts Point and Wards Island (Figure 9).

There was not a large difference in concentration levels in a locality when people were in that locality compared to that locality being empty (figure 2). Figure 4 demonstrates on average having people in a locality as opposed to having that locality empty was not significant (means were within one standard deviation of each other). Seeing how all localities had to be sampled in a certain time, there was a limit of time that one locality could have been sampled, therefore the sample time may not have been enough. The ideal way to conduct this project would have been to have a sensor in all the localities and sample concurrently. Because of lack of materials, this wasn't able to happen, and moving quickly between localities would ensure a reasonable snapshot of the PM levels in different localities of the building.

Conclusion

- The hypothesis of P.M. levels will exceed E.P.A. standards is incorrect. All localities measured in the school, except for one, were under the E.P.A.'s yearly exposure rate of 15 ug/m3. Not including the locality that violated the standards, the range of P.M. concentrations was 2.82 ug/m3 to 11.50 ug/m3.
- The one locality that exceeded the EPA standards which was the staircase located on the southeast of the building had PM levels of 20.96 ug/m3 without people and 21.98 ug/m3 with people.
- According to the EPA, PM levels should have increased when people were in a locality. From the data collect, there wasn't a large difference in Particulate counts between people being in a locality and an empty locality. Because it was important to acquire data from all localities in a timely manner so that PM levels will not change, only one minute was spent in a locality without people and one minute with people.
- Localities in the eastern part of the building had some of the lowest PM levels, even though there are two major highways on that side of the school building. While the experiment was being conducted, wind prevailed from the east-southeast, where the highways are located.

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Annexes

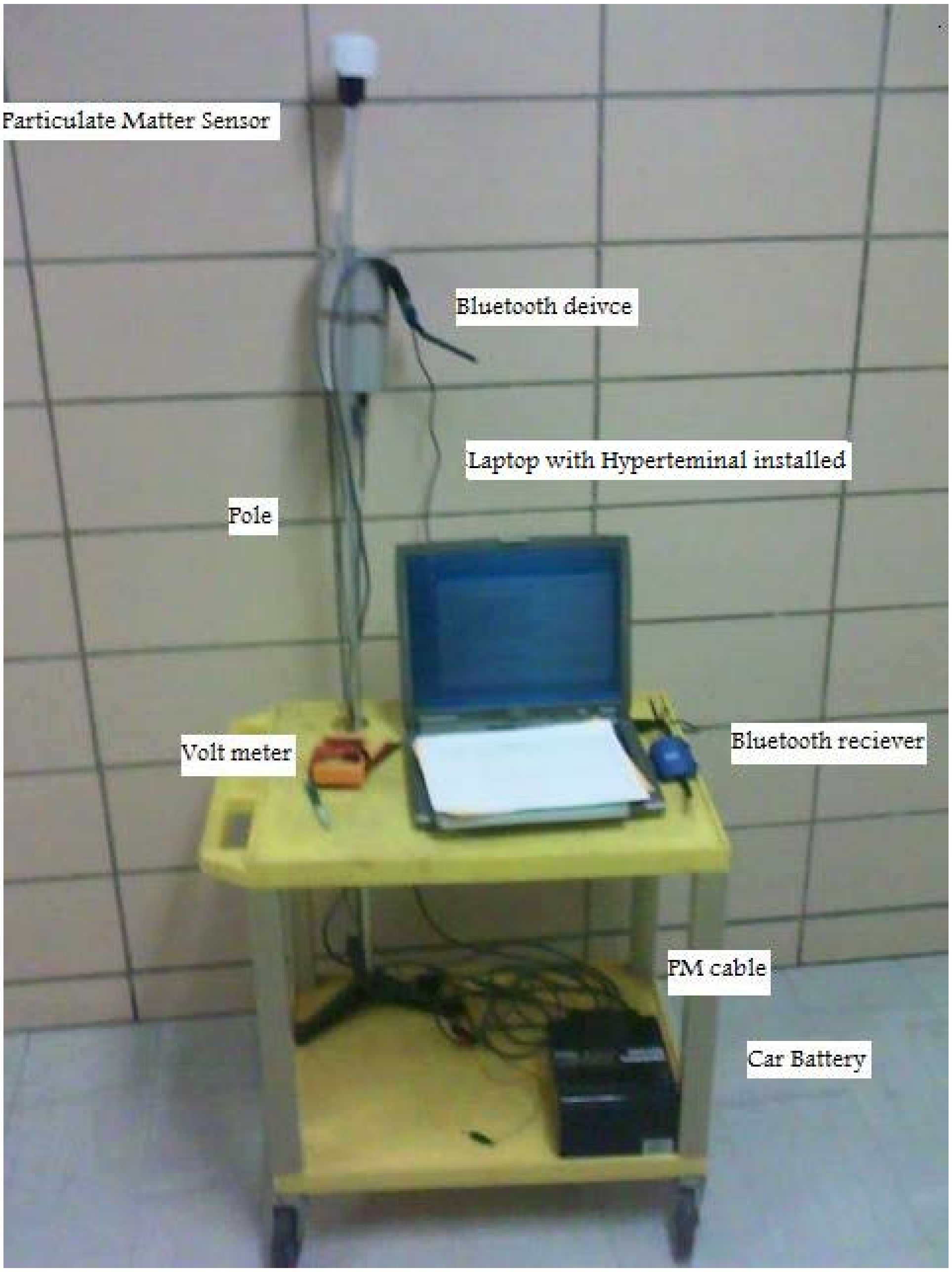

Figure 6 The above picture is the set up of the actual project. Refer to the materials list for details of the materials shown.

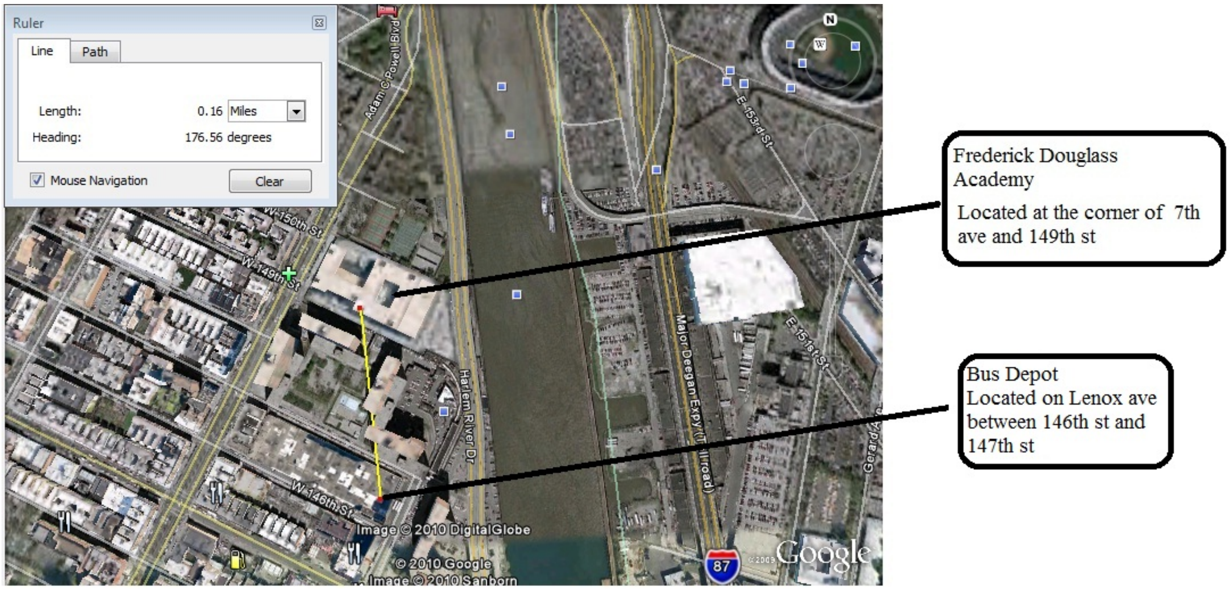

Figure 7 – The above image is of the Frederick Douglass Academy and its relationship to the bus depot in terms of distance. Wind will usually prevail from the south.

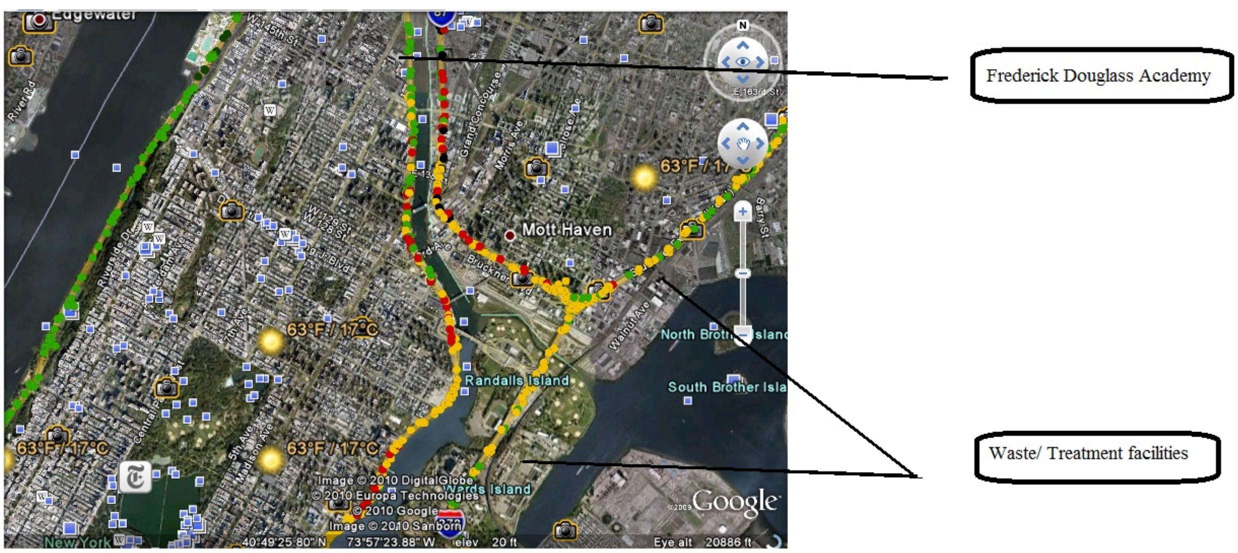

Figure 8 – The image above is the relationship in distance that the Frederick Douglass Academy has to two waste treatment facilities. There are also two major highways that are near the school which are the FDR drive and Major Deegan Expressway. On the day of experimentation, wind prevailed from the east south-east.