First Findings Report from the Manchester Air Quality Monitoring Project

Manchester Health Department, The Nature Conservancy in New Hampshire, and the Manchester, NH Branch of the National Association for the Advancement of Colored People, in Consultation with the New Hampshire Department of Environmental Services

The Manchester Health Department (MHD), The Nature Conservancy (TNC), and the Manchester, NH branch of the National Association for the Advancement of Colored People (NAACP) are pleased to present this first findings report from an ongoing project to monitor air quality across the city using low cost, yet robust, air quality sensors. This brief report is broken into the following three sections, Implementation, Challenges, and Findings to date.

Implementation:

The air quality monitoring study in Manchester is now underway thanks to a team of volunteer members from the Manchester Health Department, The Nature Conservancy, and the Manchester NH branch of the National Association for the Advancement of Colored People (NAACP), and is done in consultation with the New Hampshire Department of Environmental Services Air Resources Division (NHDES-ARD).

The team determined where to place air quality monitors by breaking down the city into eight zones and targeting key neighborhoods within those zones. Specific locations were then narrowed in on via a vetting process that included outreach to building owners and/or managers to discuss the purpose of the study and its associated air quality monitoring needs. Members of the project team then visited the potential monitoring sites to conduct a visual inspection of the property. Key objectives of these inspections included identifying nearby usable sources of 120v power and suitable points for physically attaching the monitors to the structure. In some cases, infrastructure such as fence posts or light poles could be used for mounting the monitors. The final item on the inspection checklist was to confirm the availability and signal strength of WiFi networks on the property.

Over the past two years, the team has successfully identified and vetted seven locations across six of Manchester's twelve wards and has installed a PurpleAir™ particulate matter monitor at each of these sites. PurpleAir™ monitors were chosen because of their low cost and their research-proven ability to produce $PM_{2.5}$ (Particles smaller than 2.5 microns in diameter) monitoring that is reasonably consistent compared with much more expensive federally approved equipment. Since the technology of the PurpleAir™ monitors produces a small degree of difference when directly compared to measurements collected by federally approved equipment, a mathematical correction is performed on the PurpleAir™ data to allow a more direct comparison.

Challenges:

There have been three main challenges in getting the program off the ground and keeping the data collection process running smoothly:

1. First, as with any endeavor that relies on volunteer efforts, the people participating in the planning and implementation of the program have jobs and responsibilities outside of this project. This overarching issue has cut across multiple areas of challenge for the project since these challenges need the attention and time of volunteers to be addressed.

2. The second challenge has been the identification of suitable locations and willing participants who could host a monitor on their property. Of the two aforementioned qualifiers, finding suitable locations has been the bigger challenge.

    - The planning team has identified many buildings around the city in locations of scientific interest to the team and NHDES-ARD staff in particular, where a monitor would potentially record useful and interesting data. A significant number of these locations of interest, however, don't have at least one of the main vetting criteria (outdoor power, reliable WiFi, and a good physical mounting location) for a suitable monitor installation. Of these, access to outdoor power is usually the biggest culprit in ruling out an otherwise viable location. Many of the locations that fall into this category are older buildings that are much less likely to have exterior power, and if they do it might be in highly visible or accessible locations that are more prone to inadvertent or purposeful tampering.
    - Finding a relatively easy mounting location at the appropriate height off the ground is the next most common issue that rules out a potential host site. Many of the buildings that were inspected by the team are of brick or some other masonry construction which makes mounting these monitors much more complicated. Regardless of construction type, some building owners prefer not to participate in the study and therefore do not wish to host a monitor.

3. Finally, reliable Wi-Fi has been a challenge at certain locations, though this is the least common hurdle of the three necessary criteria. Unreliable Wi-Fi has ruled out a number of locations that would have otherwise been a solid fit, because having reliable Wi-Fi is no less crucial than trying to address the other two challenges. Without Wi-Fi access there is no way for these monitors to report the data they are collecting. The team has overcome this challenge in a couple of locations by installing Wi-Fi boosters to ensure a more robust signal, which is a very helpful remedy in this type of situation.

Findings to date:

$PM_{2.5}$ data collection began at various dates in 2023 and 2024, depending on location. The following data summary details findings during a period when all the monitors operated simultaneously to allow for apples-to apples comparisons of city locations. This period ran from August 19, 2024 through the end of the year of 2024. Figure 1 shows the location of the seven monitor locations that are currently operational. Note that the map shows "MHT1/3 NW" indicating that the MHT1 monitoring device was taken out of service due to operational issues and replaced with a new device designated as MHT3. The monitoring location remained consistent. Also note that the monitor for MHT6 at the UU Church is referenced in the following

graphs as simply “UUC.” Other monitoring locations are as follows; MHT2 and MHT1/3 are located at schools, MHT4 and MHT5 are located at personal residences, and MHT7 and MHT9 are located at senior residential villages.

Figure 1: Monitor Naming and Location

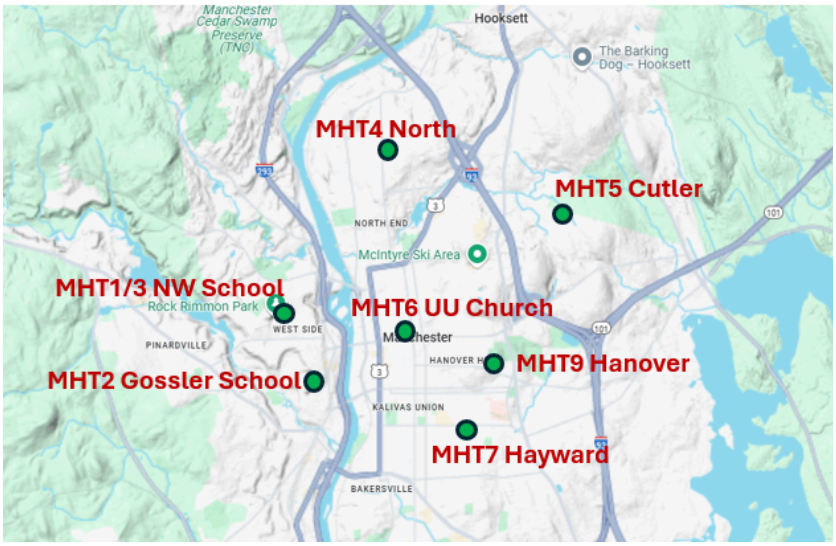


Figure 2 presents 10-minute average $PM_{2.5}$ concentrations at several statistical thresholds. For example, the 98th percentile threshold indicates that 98% of the measured concentrations were lower than the listed concentration and only 2% were higher. The 98% percentile is the same threshold used by EPA and the State of NH, but on a 24-hour average basis, to determine if an area meets the federal ambient air quality standard for $PM_{2.5}$. Therefore, concentrations of these 1-minute $PM_{2.5}$ concentrations would have to remain above 35 micrograms per cubic meter ($\mu g/m^3$), on average, for a 24-hour period to exceed this federal health standard. The chart indicates that MHT7 experienced the highest concentrations out of the seven current locations. MHT7 was closely followed by MHT2 and MHT4. The chart also indicates that MHT5 was the lowest at all thresholds. The 98th percentile suggests that MHT1/3 and UUC were fairly similar, but the monitor at MHT1/3 suffered a power failure due to squirrel damage. The monitor was then shut down in late September until a permanent fix could be implemented. UUC was low at the 98th percentile, but only due to a monitor malfunction during a relatively high concentration period. Overall, there were not huge concentration differences found among the monitoring sites. It should be noted that only federally approved equipment can be used to officially determine whether air quality meets federal health standards. However, low-cost sensors such as PurpleAir™ monitors are nevertheless useful in comparing air quality with health standards in an unofficial capacity. To this end, Figure 2 shows that $PM_{2.5}$ levels at every location are well below the level of the federal 24-hour $PM_{2.5}$ health standard which is 35 $\mu g/m^3$.

Figure 2: 24-Hour Average Concentrations at Various Statistical Thresholds

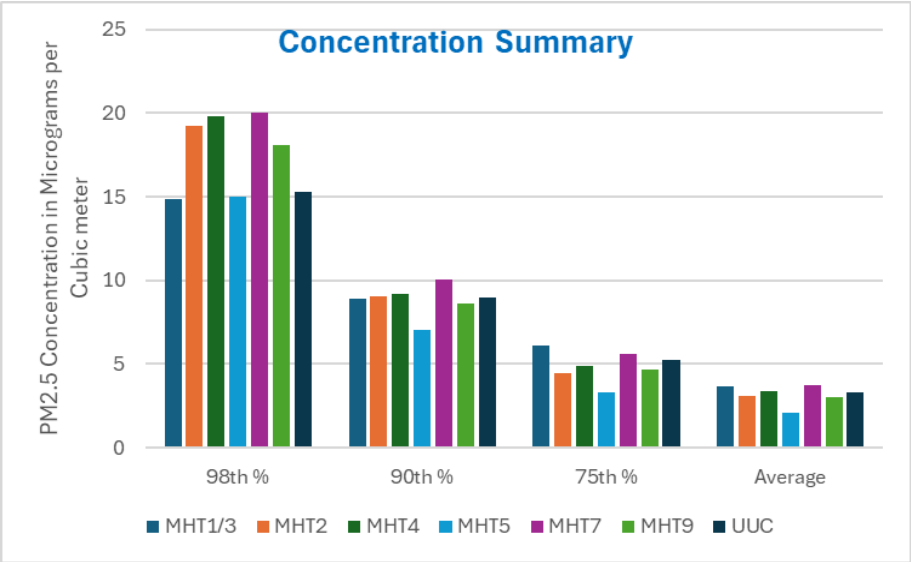
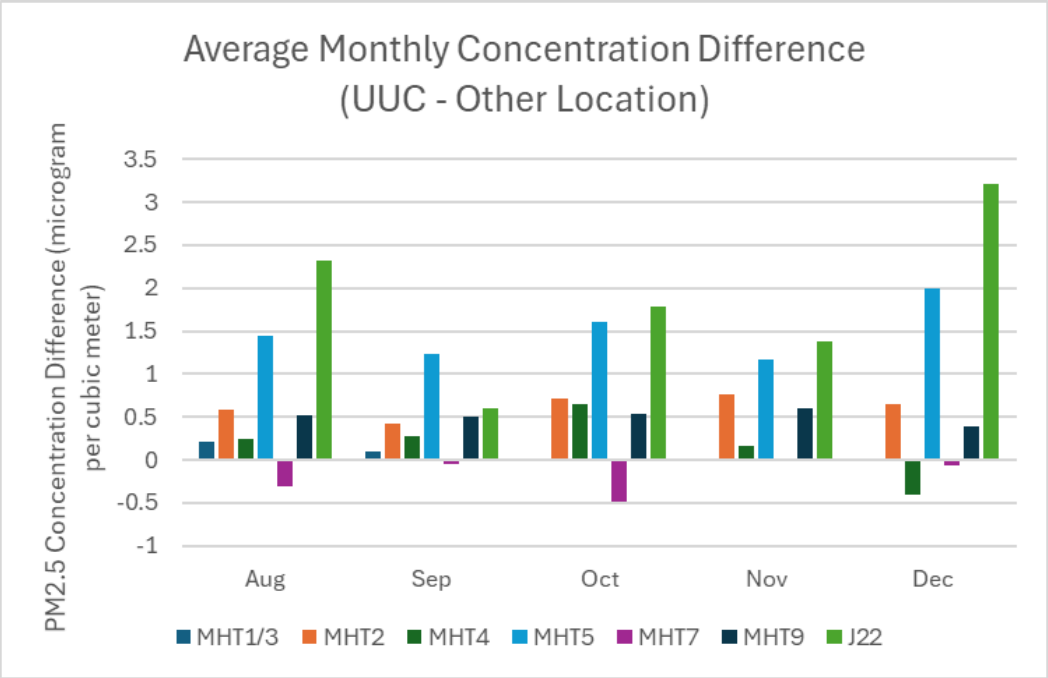


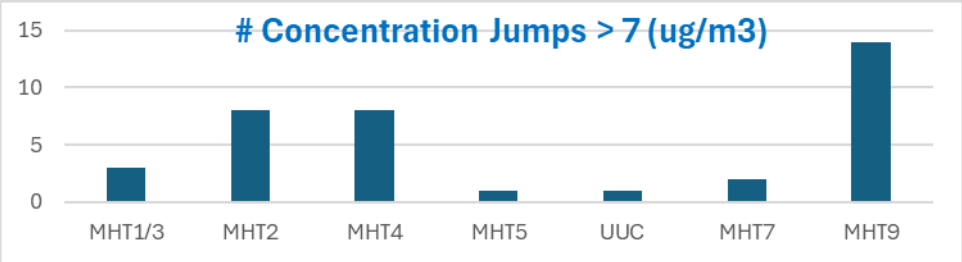
Figure 3 helps to break down the $PM_{2.5}$ concentration difference between locations. This figure compares the concentration differences averaged for five individual months. In all cases, the chart subtracts concentrations from the six monitors from the UUC concentration. UUC was chosen as the baseline for comparison since it was the most centrally located monitor. Monitor “J22” is located outside the city to the northwest, in the hills of Bow, at a private residence. It is included to provide a comparison of “city” vs “not affected by city” $PM_{2.5}$ emission sources. Similar to Figure 2, concentrations were not available in October, November, and December for MHT1/3 and some data is missing. Bars extending below the X-axis indicate that concentrations were lower at the various monitors compared to concentrations at UUC. When bars extend above the axis, then UUC was cleaner than the other location. As might be expected, $PM_{2.5}$ concentrations were lowest for most months at the rural location, J22. The blue bar for MHT5 shows that this residential neighborhood has consistently experienced the lowest concentrations thus far. On the other hand, MHT7 has experienced the highest concentrations thus far for every month, except for November where it was similar to UUC.

Figure 3: Concentration Differences Between the UUC and each of the other Locations by Month



The final figure, Figure 4, counts the number of $PM_{2.5}$ concentration jumps of greater than 7 $\mu g/m^3$ during a ten-minute period. This metric is used as a measure of variable effects from nearby emission sources such as residential wood heating and idling vehicles. Of the seven monitoring locations, MHT9 experienced the most concentration jumps, caused by an unknown emission source. MHT5, MHT7, and UUC each had relatively few concentration jumps. MHT4 is located in a residential neighborhood with known wood burning, the likely cause of its higher rate of concentration jumps. MHT1/3 may be artificially low due to three months of missing data. It was on-track to have one of the highest rates of concentration jumps.

Figure 4: Number of Times that Concentrations Increased by 7 Micrograms per Cubic Meter during a 10-Minute Period



As mentioned earlier, the monitor (MHT7), located at the senior residential village on Hayward Street, has experienced slightly higher $PM_{2.5}$ concentrations than those measured at the other six locations in the city (see Figure 2). MHT5, located at a private residence on Cutler Drive, has consistently measured slightly lower concentrations than the others. Monitor locations at MHT2, MHT4, and MHT9 seem to be more affected by variable nearby emission sources than the other locations (see Figure 4), and all the "city" monitors experienced higher

concentrations than those measured outside the city (monitor J22), most likely due to typical higher urban emission density (see Figure 3).

Next Steps:

Looking forward, the team plans to deploy an additional six monitors that were obtained under a grant award from The Nature Conservancy in the coming months. These monitors will likely target locations directly east and southeast of downtown. Ideally, the group hopes to install the monitors on buildings owned by local institutions like the city offices, the library system, or the school district. Institutional buildings such as these are far less likely to change ownership and therefore represent a good opportunity for monitors to stay in the same location for many years to come and thereby collect consistent data. Independent homes and small businesses run the risk of a change in ownership, resulting in a likely disruption of monitoring at that location. However, sometimes locations like these are the only option where permission to monitor is granted in a highly targeted neighborhood.

In the coming year the team also plans to ramp up more proactive public outreach (like this report) to make sure our neighbors here in the city and other stakeholders like TNC are kept apprised of progress, what is learned, and why the findings are important.