Monitoring Air Pollution in Tirana:
A Citizen Science Approach

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Abstract

Air quality data is not available to Tirana residents despite poor air quality and its health impacts on vulnerable populations. To address this lack of data, the team used micro-sensors to monitor particulates at schools, greenspaces, and busy city areas. We found that air pollution at school drop-off times exceeded regulatory standards, as did busy city intersections, while at parks average pollution levels met air quality standards. We recommended less polluted routes for city walkers and measures to reduce particulate pollution at schools. We developed a guidebook for youth activists in Tirana to equip and empower them to expand air pollution monitoring in Tirana.

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Meet the Team

Us at final presentation night

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Table of Contents

List of Figures

List of Tables

Introduction

Introduction

In 2022, the European Environmental Agency (EEA) reported air pollution as the largest environmental health risk in Europe. People living in areas with high levels of air pollution are at higher risk for health impacts like lung diseases, strokes, and birth defects (UNEP, 2023) as air pollution is associated with 6.7 million deaths annually (WHO, 2022).

Albania's capital, Tirana, has particularly elevated levels of air pollution. The city is susceptible to air pollution mainly because the exhaust from heavy traffic and pollutants coming from construction sites around the city get trapped by the mountains. The Green Lung Project, an Albanian air quality monitoring effort supported by the EU, monitored and mapped air pollution data in Tirana from 2018 until 2023, their most recent report being published in 2021. The results from the project found that PM2.5, PM10, O3 and NO2 levels in Tirana exceeded European Union standards (Green Lungs Ajri, 2023).

Despite these efforts, there hasn't been an air quality report in Tirana since 2021, resulting in no air pollution data for the past few years (E. Prifti, personal communications, September 18, 2023).

In the absence of governmental institutions to address critical environmental issues citizen science has experienced a surge in popularity, driven by the growing demand from individuals seeking to instigate changes in pollution levels within their respective communities. One notable example in the United States is the Louisiana Bucket Brigade, initiated in 2000 to combat alarming pollution levels in the region of New Orleans known as Cancer Valley. Through this initiative, citizens were able to prevent Nucor Steel's expansion, which stopped an estimated 125 tons of particulate matter from infiltrating the air and water in their vicinity (Bucket Brigade, 2021). Such victories underscore the substantial judicial and ethical impact that citizen science can achieve.

The Environmental Center for Development Education and Networking (EDEN) is a non-governmental organization in Albania who has a goal of developing a healthy and sustainable environment focusing on clean air. The goal of this project is to investigate air pollution in Tirana through different data-gathering scenarios, mapping concentration levels, analyzing spatial and social differences in exposure, and disseminating findings with the EDEN Center volunteers and youth groups. Our objectives were as follows: 1) To identify locations for data collection 2) To understand current challenges in improving air quality in the Tirana region. 3) To collect, map, and analyze air pollution data in Tirana. 4) To plan for the continuation of the project and assess the sustainability of the effort.

Background

Tirana's Vulnerability to Air Pollution

Air pollution is a general term used to describe the many hazardous and unwanted contaminants that find their way into the air. Particulate matter (PM) is a significant pollutant which consists of small airborne particles like dust, pollen, and smoke. Particulate matter is defined by size being conventionally split into PM2.5 and PM10 where the number refers to the particulate's diameter in micrometers (Environmental Protection Agency, 2023). Exposure to PM can lead to varying respiratory and cardiovascular problems, making it a significant public health concern globally (Saini, 2022).

The city of Tirana is surrounded by mountains, confining pollutants, and preventing the toxins from dispersing freely (Figure 1). This results in an air pollution trap for Tirana (Pojani, 2011). The idea that topography has influence on pollutants is supported by a study in China which concluded that most of the polluted areas in the country were surrounded by mountains (Wen et al., 2022). Additionally, monitoring data over a 7-year period from the Sierra Nevada Mountains in the United States reported that the lowest elevation site exceeded the WHO annual PM2.5 limits by 3-4 times, with the highest elevated site being within the limits (Cisneros et al., 2014).

Figure 1: Topography of Albania
Note. From GRID-Arendal (2005): Albania, topographic map.
http://www.grida.no/resources/5345

Towards the end of each calendar year, Tirana endures heavy rainstorms (*Albania Climate: Weather Albania & Temperature By Month* , n.d.). Rain is a primary process to naturally decrease particulate matter levels in an area. The scavenging effects of precipitation on PM levels occur by the process of wet deposition, which refers to when particulates are pulled out of the air with raindrops falling to the ground (Mircea et al., 2000; Duhanyan and Roustan, 2011).

Construction

Like the natural barricade of Tirana's topography, the city's-built environment also affects air pollution concentrations. Tirana is witnessing extensive construction activities in its urban centers. Multistory apartment buildings have been constructed on the city's empty lots at a rapid pace. (2nd Environmental Performance Review of Albania | UNECE, 2012). M. M. Rahman and N. A. Ali, Faculty of Engineering at the Universiti Teknologi Brunei, examined dust pollution as an effect of extensive construction with earthwork

Tirana's Vulnerability to Air Pollution

and soil transportation being the significant sources. A study conducted in Iran researching the PM exposure in construction sites found that the drilling process resulted in high concentrations of suspended PM (Sekhavati and Yengejeh, 2023).

Figure 2: Construction of the MET Building Note. From Wikipedia Commons (2023): MET Building Tirana seen from the Pyramid of Tirana https://commons.m.wikimedia.org/wiki/File:MET_Building_Tirana_2.jpg

Vehicle Traffic

In Tirana, vehicle traffic has a pronounced impact on air pollution, largely due to the widespread use of diesel fuel.

Data from the Albania Institute of Statistics in 2022 suggests that 73.7% of vehicles in the country use diesel fuel and there was an increase from a year prior.

Figure 3: Heavy traffic in Tirana. Photograph: Armando Babani/EPA Photograph: ARMANDO BABANI/EPA

The burning of diesel fuel exhumes particulates and sulfur dioxide (SO2) into the city's airshed. Albanian domestic diesel, which is heavily favored and cheaper than imported fuel, can reach up to 2000 ppm sulfur and exceeds the EU standard (50 ppm) by 4000%. SO2 reacts with other compounds when it is released into the air; this creates small particles that contribute to PM pollution (Mulla et al., n.d; Bader, 2008).

Urban areas of Tirana are polluted by public transportation due to outdated and heavy pollutant-emitting vehicles (Gjoka and Delli, 2019 as cited in Instituti i Shëndetit Publik, 2014). Areas like bus stations frequently expose people to such vehicles.

The Ministry of Health and Social Protection in Albania along with the Department of Civil and Environmental Engineering of the University of Pittsburgh monitored 61 municipalities across Albania to assess

For vulnerable populations like children, exposure of PM2.5 and PM10 can be detrimental. One study included a compilation of data and different projects analyzing the effects of pick up and drop off. During drop off times, cars idling intensify the level of PM2.5 by ~3-times (Kumar, 2020). This level of pollution is particularly concerning and can cause adverse health effects in children like asthma, bronchitis, and decreased respiratory ability. These elevated levels of PM 2.5 can also be seen inside classrooms and playgrounds (Kumar, 2020).

Air Pollution Guidelines and Trends

To protect citizens' exposure to prominent levels of air pollutants, the European Union (EU) has established air quality directives for each of the major air pollutants based on the safe limits for both acute and long-term exposure.

Albania is currently a candidate for EU membership with air pollution being one area preventing the country from joining (European Commission, 2022).

In addition to the EU Air Quality Directives, the World Health Organization (WHO) has published guidelines for urban air pollution based on the most recent health research. In 2023, they stated that 5 µg/m³ is a safe concentration of PM2.5 in terms of annual exposure; similarly, 15 µg/m³ is a safe level for PM10. As more research shows the negative effects of air pollution, these guidelines become stricter. The WHO standards represent the ideal pollution level at which virtually no premature deaths could be attributed to poor air quality.

Air Pollution Trends

In 2022, an independent monitoring station from IQAir in central Tirana estimated that Tirana's annual PM2.5 concentration was 2.9 times greater than the WHO annual air quality guideline (Tirana Air Quality Index (AQI) and Albania Air Pollution | IQAir, 2023). The Green Lung Project recorded pollutant data from 2018 to 2023 by monitoring PM2.5 & PM10 data in close to 500 locations around Tirana.

Pollutant	Averaging Period	Objective	Concentration	Comments
$PM_{2.5}$	Annual	Limit value	25 µg/m³	
PM_{10}	24-hour	Limit value	50 µg/m³	Max 35 days/yr
PM_{10}	Annual	Limit value	40 µg/m³	

Table 1: EU Air Quality Directives
Adapted from EU Air Quality Directives (2008/50/EC, 2004/107/EC)

Air Pollution Guidelines and Trends

Their last report, released in 2021, found several areas that consistently have PM10 levels as high as 420 µg/m³ and PM2.5 levels as high as 70 µg/m³. As listed in Table 1, the EU annual exposure of 25 µg/m³ is the approved limit for PM2.5 and 40 µg/m³ is the limit for PM10. For relatively acute exposure, the EU also has a 24-hour exposure limit of 50 µg/m³ for PM10.

Overall, the PM2.5 standards for both the EU and WHO were exceeded by almost half of the monitored stations and there was a city-wide average of 18 µg/m³. Conversely, less than half the stations exceeded the PM10 standard and there was a city-wide average of 29 µg/m³.

The city-wide averages for both pollutants were within each respective standard despite many weeks doubling the EU standard, however the lower pollution levels from the COVID-19 lockdown may have influenced the long-term average.

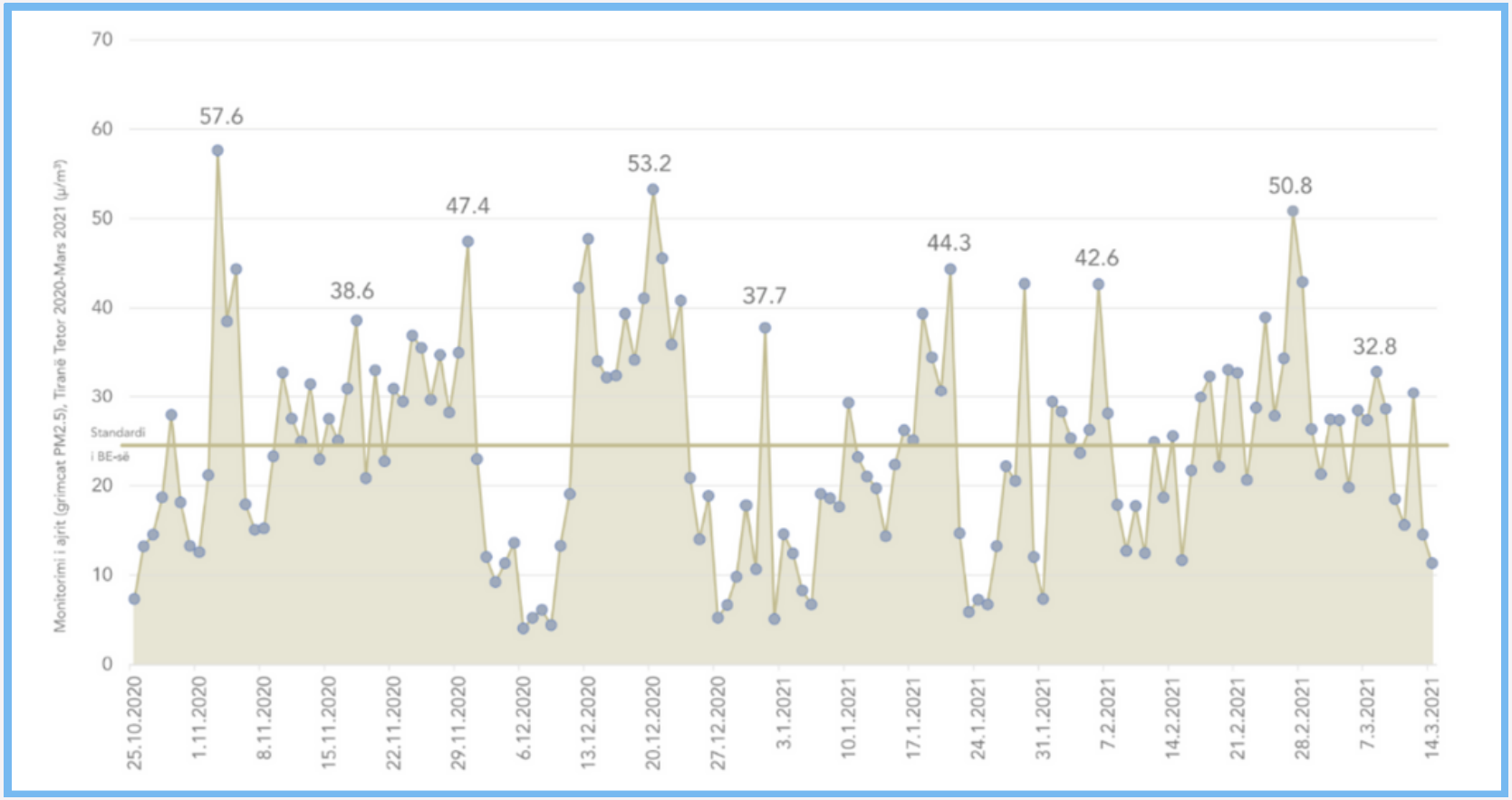


Figure 4: Weekly PM2.5 data around Tirana from October 2020 to March 2021 (Green Lung Ajri).

Health Impacts

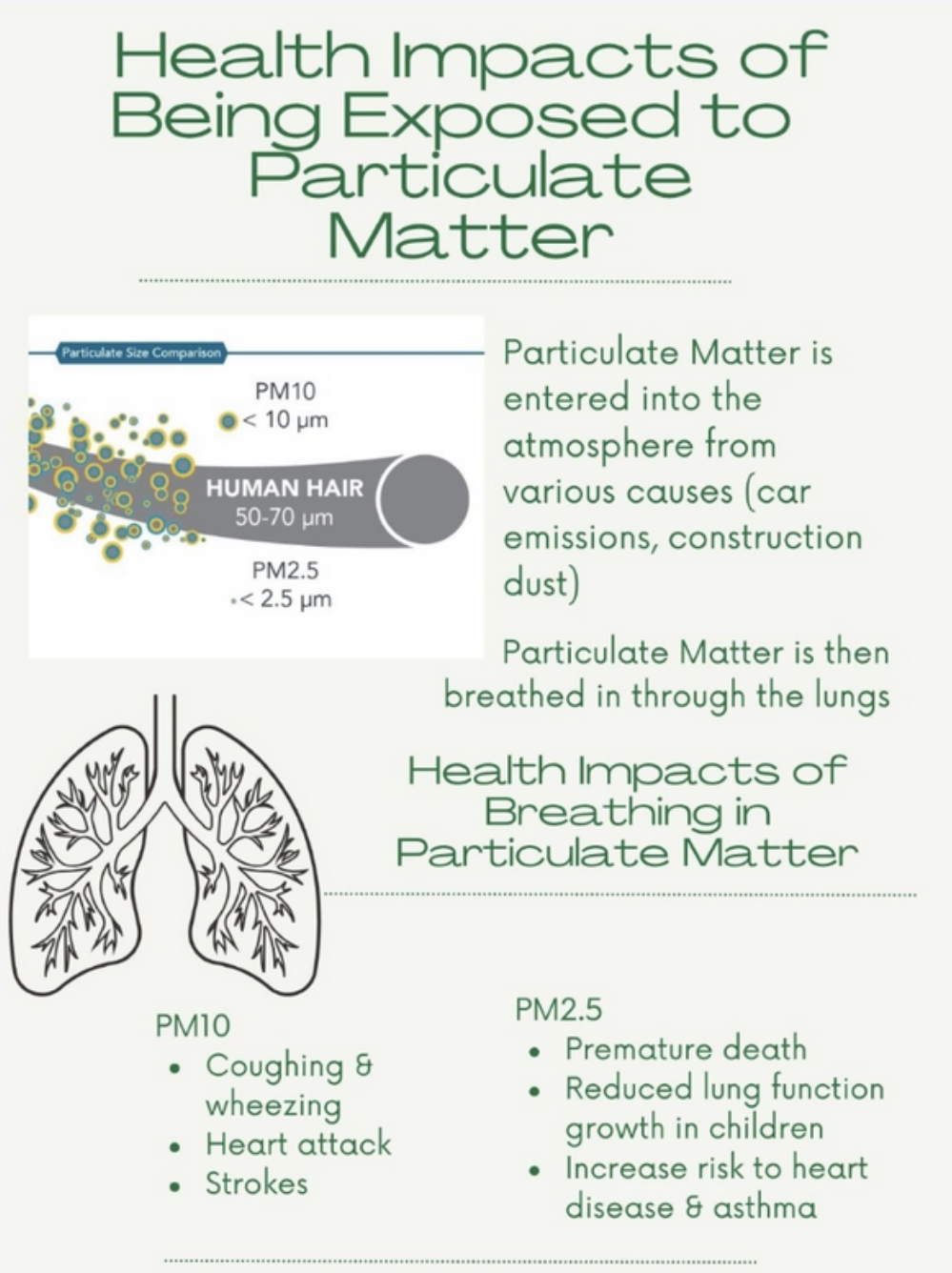


Figure 5: health impacts of particular matter infographic

Elevated air pollution levels pose a significant health concern for everyone, however, there are several particularly vulnerable populations: children under the age of 15 whose lungs are still developing, people above the age of 65 who are more susceptible to acute effects, people with pre-existing conditions such as a genetic condition, or people with weakened respiratory health as a result of smoking (Kurt et al., 2016). Information from the Institute of Statistics in 2022 reveals that more than 30% of Albanians are currently part of a susceptible age demographic. As more people grow up in polluted areas the lifelong effects are felt by an increasing number of people each year. This poses a growing health concern for Tirana. The mechanism by which particulate matter damages the respiratory system is illustrated below.

Particulate Matter can lead to several diseases with potentially fatal outcomes. A countrywide study of air pollution by the Ministry of Health and Societal Protection in Albania in 2016 concluded that for every percent increase in the concentration of PM2.5 in Albanian cities, a 32% increase in the prevalence of chronic obstructive pulmonary disease (COPD) was observed (Shehu et al., 2022). The European Environment Agency in 2019 estimated that PM2.5 caused more than 25,000 premature deaths in the Western Balkans alone, with 4,000 deaths being in Albania. The APHEA (Air Pollution and Health: a European Approach) collected PM10 data from 29 major European Cities and found that a 10 µg/m³ increase in PM10 meant a 0.76% increase in cardiovascular deaths and a 0.58% increase of respiratory deaths (Xing et al., 2016; Analitis et al., 2006).

Monitoring Initiatives in Tirana

The Green Lung for Our Cities Project sponsored by Co-PLAN, a Non-Governmental Organization with different environmental focuses and partners with POLIS University, started monitoring in 2018. The project Green Lungs for Our Cities project "... [aimed] to create an alternative and inclusive Platform for monitoring air quality, noise pollution, and evaluating the service provided by the urban greening ecosystem" (Green Lungs Ajri, n.d.) This project was driven by a desire for air pollution data related to the rapid increase of construction in the city. The responsibility of monitoring falls under the National Environment Agency (the NEA), a sub department of the Ministry of Tourism and the Environment. The NEA website only has monitoring data available to the public from 2014 (Monitoring , n.d.). Article 10 of Law No. 162/2014 "On the Protection of Environmental Air Quality" states "The Ministry should regularly make available to the public and organizations..." (Article 10 of Law No. 162/2014).

These reports should be made in a clear understandable way accessible to: environmental organizations, consumer organizations, organizations that represent the interests of the most affected population groups, other healthcare bodies, and relevant industries, traders, commercial companies, and other legal entities (Article 10 of Law No. 162/2014). There has been no regulation and implementation of this law as Green Lungs Co-PLAN, The EDEN Center, citizens, and public health representatives have not had any access to data. With no accessible, accurate government data since 2015, the founders of the project took the issue into their own hands.

Figure 6: The Ministry of Tourism and the Environment
https://en.wikipedia.org/wiki/Ministry_of_Tourism_and_Environment_(Albania)

The Green Lung project used stationary air monitoring methodology in various parts of Tirana and Albania focusing on major sources and different pollutants. The project focused on collecting measurements of PM2.5, PM10, and Nitrogen at almost 500 monitoring sites from 2018-2023. Once the data was collected and mapped, the data was sent to the government, the National Environmental Agency, other NGO'S as well as written reports published on their website, available for everyone. This project provided accessible, up-to-date, and accurate data in Albania which had been missing over the last few years.

After the Green Lung for Our Cities project ended, there was a slow decline in initiatives by the Albanian government and other companies to continue air monitoring. Vodafone Albania and the Municipality of Tirana started a project in 2020 to monitor the air pollution because of the increase of traffic and traffic congestion.

Monitoring initiatives in Tirana

The goal was to transmit the collected data to the public. The data collection focused on looking at PM2.5 and PM10 by using Vodafone's IoT technology, and smart air quality monitoring devices which are installed in the city (Monitoring Air Quality in Albania , n.d.). The data was accessible to the Tirana citizens through the application "Tirana Ime" which has general information about Tirana city for citizens to use from Vodafone. However, this project has since ended, and the data on the app is no longer accessible to the public.

Valbona Mazreku, Executive Director for environmental organization Milieukontakt International, expressed her concerns of the absence of air pollution data for the past three years (Euronews Albania, 2021).

An Air Pollution and Human Health study for the Western Balkans coordinated by members of the UN Environment sector in May 2019 were unable to analyze the impacts of PM2.5 in cities of Albania due to the PM2.5 data being "incomplete". The absence of such data poses a challenge in accurately gauging the severity of pollution and implementing measures to protect public health effectively.

Citizen Science

Figure 7: Louisiana Bucket Brigade members posing with a bucket. From: https://www.climateride.org/louisiana-bucket-brigade/

Given the concerns surrounding the severity of air pollution in Tirana and its health impacts coupled with the lack of crucial government data, it becomes important for communities to take initiative in documenting air quality through citizen science. Citizen science is an approach to research that involves the public or is entirely led by members of the public. It allows community members without a science background to participate in or take the lead on the collection, analysis, or dissemination of information. Through this method, community members can address data gaps and drive change. Citizen-generated data can be used to create pressure on governmental bodies to implement stricter regulations and take more effective actions against pollutants, ensuring a healthier environment for all.

Citizen Science

Why Monitor?

Air monitoring citizen science projects are often driven by health concerns, concerns with living near potential sources of pollution, and a general desire for more air quality knowledge. Diseases like asthma, cardiovascular ailments, and cancer are cited to be significant sources of concern among residents living in polluted areas, driving community members to engage in air quality monitoring (Commodore, 2017). Citizen science offers a platform for communities to participate in the monitoring and reporting of environmental hazards. The anticipation of positive outcomes, such as improved knowledge about air pollution, reduced pollution risks, and diminished health burdens, has also served as a motivating factor for communities to participate in these initiatives (Commodore, 2017).

Example: The Louisiana Bucket Brigade
The Louisiana Bucket Brigade (LABB) focused on significant health concerns tied to the oil and petrochemical industry in the Cancer Alley of Louisiana. They believed that emissions from these facilities could lead to respiratory problems, heart disease, cancer, and more. Without access to accurate, accessible data from the state, they took matters into their own hands using community based monitoring.

The full profiles for the citizen science examples mentioned are available in appendix A.

Figure 8: steamstacks photo

Citizen Science

What do they monitor and why?

What is monitored by a citizen science project is influenced by many factors: specific environmental concerns, available technology, and policy goals.

Example: Breathe London
The Breathe London project measures several key harmful air pollutants. These include PM10 and PM2.5 particulates, nitrogen dioxide, ozone, and sulfur dioxide. The monitoring of these pollutants is crucial for local communities, especially in urban areas where exposure to high levels of air pollution is a significant public health concern (Breathe London).

Since children are a vulnerable population when it comes to air pollution, the Breathe London team conducted a side study using wearable sensors in Spring 2019 where children from these schools were given wearable sensors, which they carried to and from school over a period of five school days (Breathe London).

Figure 9: The bucket used by the Louisiana Bucket Brigade. From: https://www.youtube.com/watch?v=WAOeTvRju7A

Figure 10: The air pollution monitoring node used by the Breathe London project. From: https://www.breathelondon.org/location-installation

Example: The Louisiana Bucket Brigade
The Louisiana Bucket Brigade conducted monitoring variety of air pollutants, focusing on vinyl chloride, ethylene dichloride (EDC). and benzene. They focused on these since their community, impacted by industrial activities, displayed violations of Louisiana's standards, and were considered toxic and carcinogenic. The bucket monitor is an EPA approved device. It is a bucket with a Tedlar bag inside that can collect air samples which can be tested at a lab. This allows for detecting about 100 toxic gases. The Louisiana Bucket Brigade's monitoring focuses on specific air pollutants detrimental to community health, particularly in areas adjacent to industrial facilities (Louisiana Bucket Brigade).

Citizen Science

Building Membership, Community Involvement, and Sustainability in Citizen Science Projects

Citizen science initiatives can achieve success in sustaining membership through a variety of approaches. The community, equipped with firsthand experience and nuanced understanding of local environmental issues, can drive impactful initiatives, fostering a culture of active participation and sustained activism. One of the core strategies employed by these initiatives is the active participation of community members in scientific processes. Involving the community in the planning, execution, and interpretation stages of the projects in addition to data collection not only ensures the use of local expertise but also instills a sense of ownership and agency among the participants. This factor is crucial in ensuring the long-term sustainability of environmental projects, fostering a legacy of continued activism and change (Donkers, 2022). Sufficient training also plays a role in sustaining membership. Projects need to equip community members with the necessary tools and knowledge to effectively monitor air quality. Similarly, the opportunity to incorporate personal narratives through diaries, photographs, and stories adds a layer of personal connection to the scientific data, making the experience more relatable and engaging for the participants (Commodore 2017).

Example: Breathe London
Children's participation in monitoring activities significantly increased their awareness and understanding of air pollution issues. This enhanced understanding enabled them to analyze their own exposure to air pollution and contemplate ways to reduce it. Such educational outcomes are not only beneficial for the individual participants but also contribute to the broader goal of raising community-wide awareness about air pollution and increasing interest in future activism (Breathe London).

Figure 11: Group protesting air pollution in India
From: https://zeenews.india.com/news/photogallery/citizens-protest-against-air-pollution-1946991

Citizen Science

Data Dissemination and Impact

Citizen science research tends to struggle when it comes to creating an impact on policy. This is because the results are not often trusted by policymakers. A major concern in utilizing low-cost sensors for air quality monitoring is data quality and accuracy. Sensor validation is crucial, involving inter-sensor variability checks and comparison with official air quality monitoring data. A study demonstrated the high accuracy of a particular air sensor known as CoSense Units when compared to official monitoring data, suggesting that well-validated low-cost sensors could supplement official environmental monitoring systems (Mahajan 2022).

Effectively communicating and disseminating research data to the community is critical to air pollution monitoring projects. Delivering information in a way that is accessible and comprehensible to residents can be challenging. One of these challenges is in finding a balance between evoking a sense of urgency without resorting to fear (Parant, 2016). The end goal is not to foster a feeling of doom and hopelessness, therefore presenting solutions and actionable advice is vital. Data dissemination can empower community members to engage in local environmental decision-making and make efficient use of the data for implementing pollution reduction strategies (Commodore 2017).

Various monitoring projects have tackled this challenge by offering multiple resources for real-time access to air quality data, including websites, telephone lines, and even flag systems. Today, technology allows for near real-time data retrieval and dissemination through air pollution sensors and telemetry, which transmit data to portable devices from various monitoring locations (Commodore 2017).

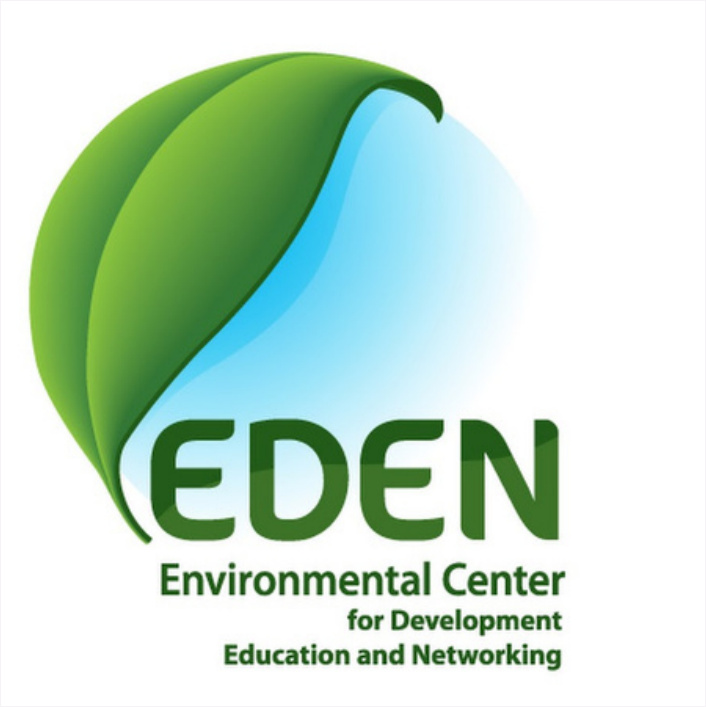
Figure 12: Air monitors used by students as a part of the Oslo Project
From: https://www.frontiersin.org/articles/10.3389/fclim.2021.639128/full

Example: The Oslo Project

The data collected by this project was mapped using ArcGIS Pro and is available to this day along with the data collected the toolbox lesson and template were disseminated through many different languages. The curriculum from this project can still be seen in primary school science classes (Castell 2021).

The Environmental Center for Development and Networking

The EDEN Center is a local non-governmental organization that works with enthusiastic youth in the community who want to get engaged and learn more about environmental issues in Albania. The EDEN Center empowers youth to be a part of the change. This is done by hosting workshops educating, engaging, and having a participating impact. The EDEN Center recently hosted the “Tirana Youth Climate Summit” and “Youth4CleanAir” hub. The climate summit allowed anyone in the community to come to the Tirana Zoo and learn more about the climate issues that are happening in Albania, specifically in Tirana. It was also a place for them to voice their ideas and collaborate. The “Youth4CleanAir” hub is an outlet for the EDEN Center to encourage the creation of innovative techniques to spread information on air pollution.



Approach

Approach

Objectives

1. **To identify locations where data collection will take place**
2. **To understand current challenges in improving air quality in the Tirana region**
3. **To collect, map, and analyze air pollution data in Tirana**
4. **To plan for the continuation of the project and assess the sustainability of the effort**

The goal of this project was to investigate air pollution in Tirana through different data-gathering scenarios, mapping concentration levels, analyzing spatial and social differences in exposure, and then sharing our findings with the EDEN Center volunteers and youth groups.

To prioritize data collection scenarios and locations, we considered the motivations of our sponsors, the EDEN Center, and the needs of local youth activists. Through various informal discussions at meetings and climate change events with activists, we came to understand what issues concerned them most regarding air pollution. From the conversations and our research, some concerns we noticed were the following:

- What are the levels of air pollution pedestrians experience?
- How do green spaces serve as havens in a polluted city?
- How do different street characteristics affect pedestrian exposure to pollutants?
- How much pollution are children exposed to on the way to and from school?
- What are the safe routes to green spaces?

Figure 13: The new boulevard

Approach

In the fall, Tirana experienced more rainfall than it does in the rest of the year. Out of twenty-four days of potential fieldwork, we conducted monitoring in either one or two sessions over eleven days. On ten of these days, monitoring occurred 24-48 hours after rainfall. It's important to note that rain removes most particulate pollution from the air and pollution levels build up following each storm. During our only chance to monitor over 72 hours after rain, we observed pollution levels two to four times higher than previous readings in the same area (Appendix E). As a result, all data presented below may show significantly lower air pollution levels than is typical year-round in Tirana.

Locations	**Location Type**	**Justification**
The Grand Park and the Artificial Lake Tirana Zoo The Botanical Garden	Green Space	These sites attract a considerable number of visitors and are often frequented by vulnerable populations such as children and the elderly.
Routes to Green Space	City Roads	Many people may be exposed to pollutant as they walk towards green spaces
Rruga Teodor Keko New Boulevard Bulevardi Dëshmorët e Kombit (Main Boulevard) Blloku (Block)	High Traffic Areas	These roads all experience high traffic during morning and evening rush hour. These roads may be pollution hotspots.
Skanderbeg Square	High Foot Traffic	Skanderbeg Square is a large public, pedestrian square surrounded by vehicular movement.
Shkolla 9-vjeçare konferenca e pezes, Shkolla 9-vjeçare "Lidhja e Prizrenit," Shkolla 9-vjeçare "Edith Durham."	Schools	During pick up and drop off schools are areas of heavy traffic. Children who are exposed to this pollution are a significant vulnerable population.
Alleyways in: The Block between Rruga e Durrësit and Rruga Myslym Shyri	Alleyways	Alleyways may trap pollutants, leading to higher exposure levels for residents.
Bus Stations along: Bulevardi Gjergj Fishta Kavaja St	Bus Stations	Bus stations are potential hotspots for air pollution, due to idling engines and the influx of diesel buses.

Table 2: List of monitor viewing locations and justifications

Approach

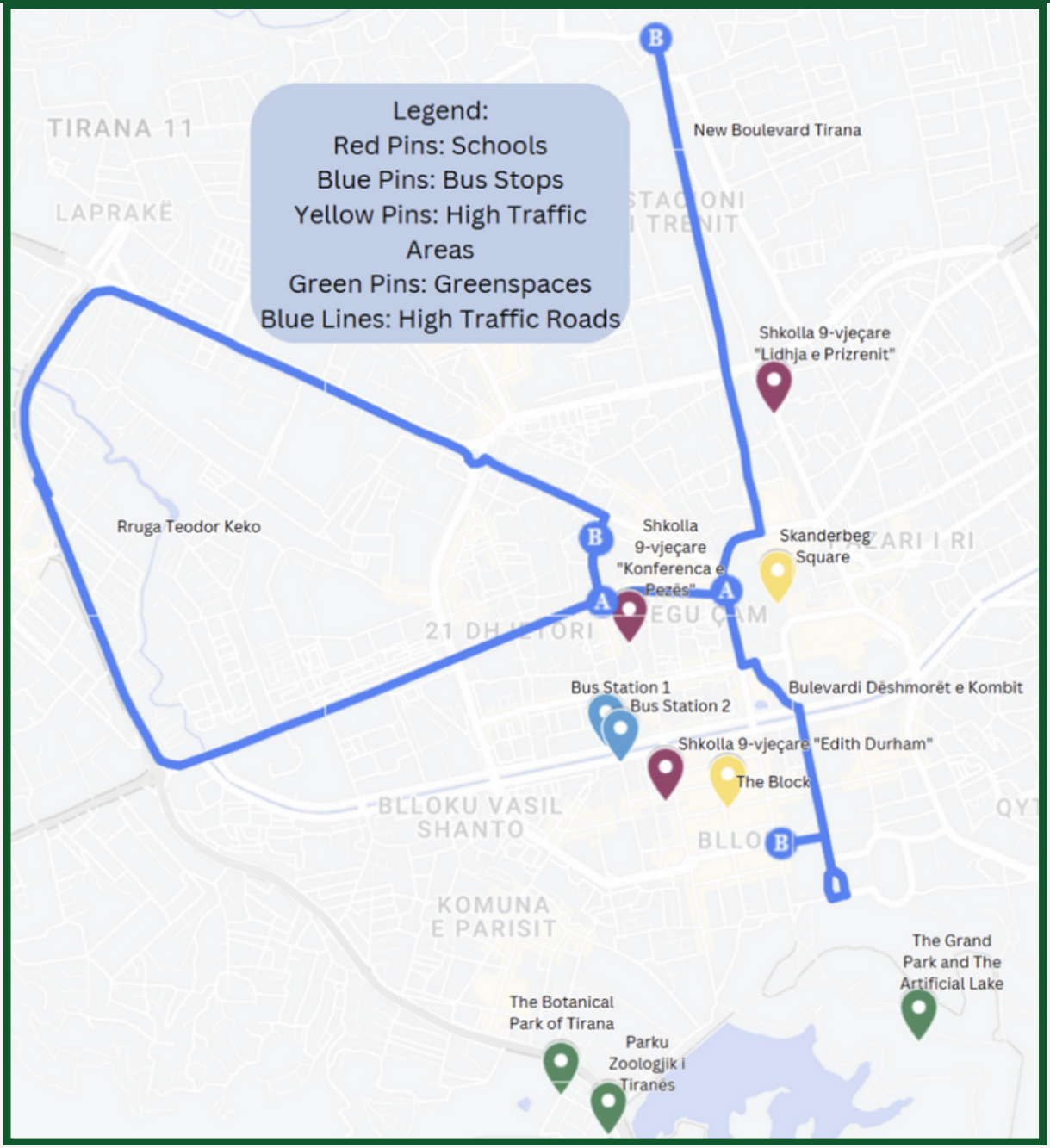


Figure 14: This figure shows all the major locations where we monitored. The pins are color-coded by the type of location. Not pictured: The various alleyways visited. The alleyways were located near Rruga e Bogdaneve and the Block out of convenience.

To identify current gaps in the air monitoring system in the Tirana region.

To understand the challenges of air pollution and air pollution monitoring, we interviewed Rodion Gjoka, a professor at POLIS University and one of the founding members of the GreenLung project with a deep understanding of the technical and social aspects of the project. We discussed the organizational structure, the project members, and the monitoring protocol of the GreenLung project, using the information as a foundation for our work. Additionally, we inquired about the history of environmental action and the difficulties of air pollution monitoring in Albania. The interview questions can be found in Appendix C.

The Green-AL "Empower Grass-Root CSOs for Improved Innovative Environmental Protection in Albania" is a program implemented in 2021 by Co-PLAN as well as other sustainable development NGOs.

Approach

The program contributed to empowering NGOs by increasing awareness, addressing environmental issues, along with funding 31 projects across Albania. On December 7th, we attended Green-AL's "From Vision to Action, for a Greener Future", a project closure conference signifying the end of the first phase of the project, which ended in 2023. At this conference, we discussed the priorities, interests, objectives, and challenges of several environmental NGO's present. Speakers from the Swedish Embassy in Tirana, Ministry of Environment, and European Environment Bureau (EEB) were also present.

Understanding the work done by NGOs is important for a better grasp on the current landscape of environmental, air pollution work in Tirana, and the factors that lead to the end of long-term efforts.

To learn the process of obtaining air monitoring data from the government and understand Albania's complicity with EU requirements, we exchanged emails with a lawyer.

The purpose of this was to assess what steps a citizen would need to take to get air pollution data in Tirana.

We also inquired on the specific regulations imposed by the EU on the Ministry of Tourism and Environment. Albania is not an official EU member; however, their candidate status requires that they follow EU regulations to become a member.

To gain insight on the current practices of urban planning and the role of air pollution data in benefiting future construction projects, we interviewed Gyst Selhort, a managing partner at Jeshile which is a landscaping company in the field of sustainable public space planning.

To collect, analyze, and map the data of air pollution in Tirana.

To collect air pollution data in Tirana, this project utilized the Atmotube Pro microsensor to measure particulate matter concentrations at their respective GPS coordinates.

Figure 15: The Atmotube Pro model used in this project

The Atmotube Pro microsensors are equipped with auto-calibration software and are designed to retain precision over many years. It is capable of measuring PM2.5 and PM10 up to 1000 µg/m3 with an error margin of ±10% above 100 µg/m³ and an error margin of ±10 µg/m³ below that level. The Atmotube Pro does not allow for user calibration.

Approach

Monitoring was done according to one of two protocols either stationary monitoring or walking monitoring. Walking monitoring was used to gather air pollution data over an area, or along a route, typically used to evaluate the pollution exposure risk to pedestrians. Stationary monitoring is used to examine the air pollution at a certain point, like a specific intersection or at a school entrance during drop-off time. Both methods involve taking data for between 30 minutes and two hours.

When measuring air pollutants, there were some cases that called for the exclusion of a particular data point. Excluding a data point was considered a weighty decision and was only done after careful consideration.

The circumstances resulting in exclusion were outliers not representative of air pollution levels in an area, for example passing by a smoker or a train in the park. To support this, we took extensive field notes during monitoring, especially regarding anything atypical (Appendix D).

Once data was taken it was loaded into Excel and referenced against the notes for that monitoring session. Immediate surroundings were carefully considered; sampling next to idling cars or in proximity to a person smoking could yield extreme results not indicative of typical air quality in the area. Any measurements influenced by such factors were discarded with appropriate justifications to avoid a skewed set of data. To mitigate local discrepancies, all presented data reflects averages derived from multiple readings on different sensors in each area or a collection of data points along a path. Two mapping programs were used, Google MyMaps and ArcGIS Pro.

Figure 16: Example of map on Google MyMaps

For the map on Google MyMaps, each marker represents the average of at least 15 minutes spent at that location. This was used to illustrate static measurements like schools during drop-off time.

Approach

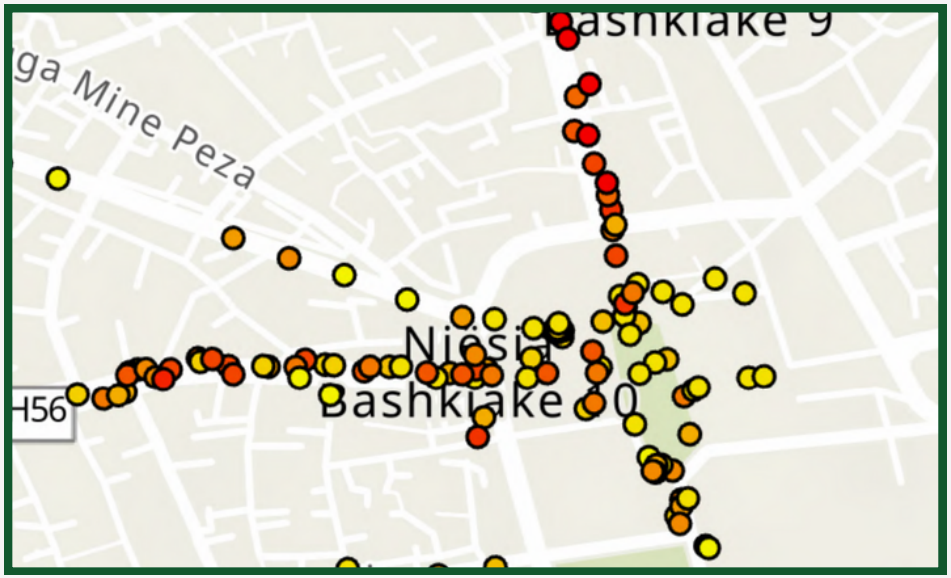


Figure 17: Example of Skanderbeg Square on ArcGIS Pro

For the ArcGIS map each data point was loaded in and rendered using the GPS coordinates logged by Atmotube Pro. This was to represent many of the larger areas and routes which were measured while walking.

When the data was uploaded into ArcGIS, the points of high PM2.5 and PM10 are shown in darker red, and the lower levels are in a lighter color red or yellow. The representation of the data on these maps allows for the high levels of PM to be easily identified and what type of hotspots are found in different areas.

The maps were used as a tool to understand the data collected. Using this visual representation to see the pollution levels throughout the city combined with using the EU and WHO standards to contextualize the numerical readings we were able to get a clear picture of the air pollution in the areas we monitored within Tirana.

To plan for the continuation of the project and assess the sustainability of the effort.

To facilitate a successful transfer of materials and knowledge gained during this project, our project included a workshop and walkthrough to share our experiences using the sensors with youth activists. Eleven individuals attended the workshop and walkthrough on Saturday, December 6th at the EDEN Center Office.

The goals of this workshop included familiarizing the scope of air pollution and recent air pollution monitoring in Albania, introducing monitoring protocol, and understanding the feasibility of continuing a monitoring program from a youth perspective.

The introductory presentation began with an overview of air pollution in Tirana and air pollution monitoring. The first portion summarized what pollutants and their sources are present in Tirana.

Approach

Focusing on monitoring, we shared the current state of accessing air pollution data and showed the Green Lung Project as a prominent air pollution monitoring project. Through describing two citizen science initiatives, we aimed to show activists that when data is unavailable, it can be created by them.

The second portion of the presentation revolved around Atmotube Pro monitoring and protocol. We demonstrated the basic function of the Atmotube Pro sensor and the interpretation of its Excel output.

Then, we took the group outside the EDEN Center building for 10 minutes with three monitors. As we walked, we observed data altering sources such as cars and smoking with the group. Upon return, the data was analyzed and mapped. After sharing examples of our maps using Google MyMaps, we uploaded each data set to create a map.

The final portion of the program was a discussion with the youth activists to focus on the practicality of sustaining this project from their perspective, along with any commitment issues an interested activist may have. Questions prompted in the workshop are available in Appendix J. This information, along with our observations and interactions at the Tirana Youth Summit and Elbasan “Youth4CleanAir” Hub, were used to assess the likelihood of sustaining the project from a youth perspective.

To gain understanding of sustaining the project from an NGO perspective, we discussed with the EDEN Center regarding their continued contribution and involvement in this project.

Our team also created a guidebook for activists who were unable to attend our workshop to use as a reference. The guidebook is a structured and comprehensive repository based on notes, writing, and data of our 7-week project. It includes step-by-step instructions and best practices for air pollution monitoring, sensor usage, access to proper data analysis tools, and environmental mapping.

Findings

Findings

How are pedestrians in central Tirana exposed to air pollutants as they travel around the city?

Locaton	Time of Day	Average PM2.5	Max PM2.5
Grand Park	11:00 AM - 12:30 PM	3.32	5.3
Tirana Zoo	11:05 AM-11:35 AM	3.57	3.925
Botanical Garden	11:45 AM-12:18 PM	4.36	6.475
Skanderbeg Square	11:05 AM - 11:35 AM	5.19	6.4
Shkolla 9-vjeçare "konferenca e pezes" Pick Up	10:23AM-11:24AM	5.95	17.4
Main Boulevard (Afternoon)	3:00 PM - 4:00 PM	5.99	11.7
Rruga Teodor Keko	2:00 - 5:00 PM	7.73	8.2
Shkolla 9-vjeçare "Edith Durham" Pick Up	10:16AM-10:59AM	8.34	19.65
The Block (Afternoon)	3:00 PM - 4:00 PM	9.34	25.5
Shkolla 9-vjeçare "konferenca e pezes" Drop O	7:35:00 AM - 8:10 AM	10.31	30.4
Main Boulevard (Morning)	10:00 AM - 12:00 PM	10.49	15.1
The Block (Morning)	10:00 AM - 12:00 PM	10.73	15.7
Shkolla 9-vjeçare "Edith Durham" Drop Off	8:00AM - 8:19AM	11.6	112.3
New Boulevard	9:33 - 10:35 AM	13.49	16.85
Shkolla 9-viecare "Lidhia e Prizrenit"	7:45AM - 8:09AM	25.71	37.05

Table 3: of monitored locations and pollution levels

Table 3 shows the average and max PM2.5 of all the areas we observed. Green indicates areas below the WHO annual PM2.5 guideline of 5 μg/m³, yellow indicates the areas that exceed the WHO annual PM2.5 guideline, and red indicates levels above the EU annual PM2.5 standard of 25 μg/m³. We found across all our monitoring that the PM2.5 and PM10 levels followed the same trends, however, the safe levels of PM10 are significantly higher than PM2.5 and very few of the monitoring scenarios revealed concerning PM10 measurements.

High Traffic Areas

What are the levels of air pollution pedestrians experience?

Pedestrians are exposed to the most pollutants in high traffic areas. High traffic areas are common for pedestrians, exposing them to PM2.5 from vehicle emissions while walking to work, the grocery store, café, and restaurants. Many of these areas we monitored tended to have either congestion during rush hour traffic or a continuous flow of traffic throughout the day.

Monitoring revealed that PM2.5 levels along these routes was 16.7 µg/m³. While this does not exceed the European Union regulations for annual PM2.5 exposure, it does exceed the WHO recommendations. With high PM2.5, frequent pedestrians, especially vulnerable populations, walking on these streets are faced with the threat of heart disease, asthma, and low birth rate.

Crossroads are hotspots for PM2.5 as cars idle at the stoplights and two major roads are brought together. Our data at the intersection of Rruga Teodor Keko and Rruga Dritan Hoxha, two high traffic main roads, was consistent with findings from the Green Lung Project as the PM2.5 at the intersection was 7.70 µg/m³ and the PM10 was 9.74 µg/m³.

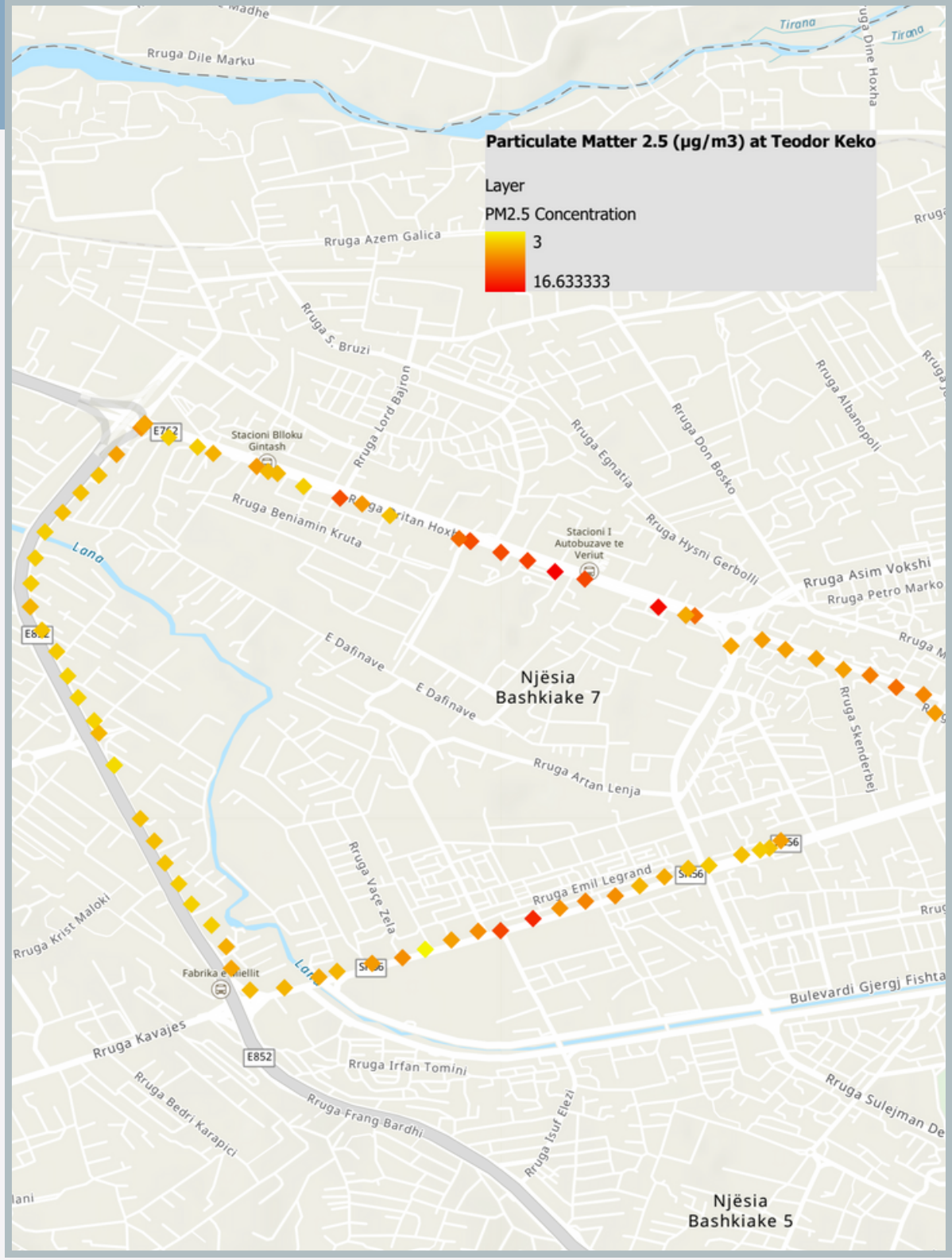


Figure 18: map of Teodor Keko

High Traffic Areas

This data exceeds the WHO annual PM2.5 recommendation by 2.7 µg/m³ making this intersection, like many others, a dangerous location for pedestrians to idle while waiting to cross the road. At these intersections, vulnerable populations may experience acute symptoms of coughing, wheezing, and shortness of breath.

Figure 19 depicts the New Boulevard and Skanderbeg Square PM2.5 (µg/m³) . The darker color points represent a higher value of PM2.5 µg/m³ in that location . The New Boulevard is a high traffic road and traffic easily backs up during both morning rush hour, 7 AM to 10 AM, and evening rush hour, 4 PM to 6 PM. The New Boulevard was monitored twice, once in the morning, 9:30 AM to 10:35 AM, and another day in the evening, 4 PM to 5 PM. The morning session was monitored one day after rain; however, the evening session was measured three days after rain, which increased the particulates in the air.

Based on our data, the New Boulevard has some of the highest concentration of both PM2.5 and PM10 out of all the high traffic areas. The lowest point of PM2.5 measured at 8.1 µg/m³, which happened to be the only point that met the EU standard. The highest point measured at 57.7 µg/m³ and was at the intersection of the Boulevard Zogu I which connects the New Boulevard to Skanderbeg Square.

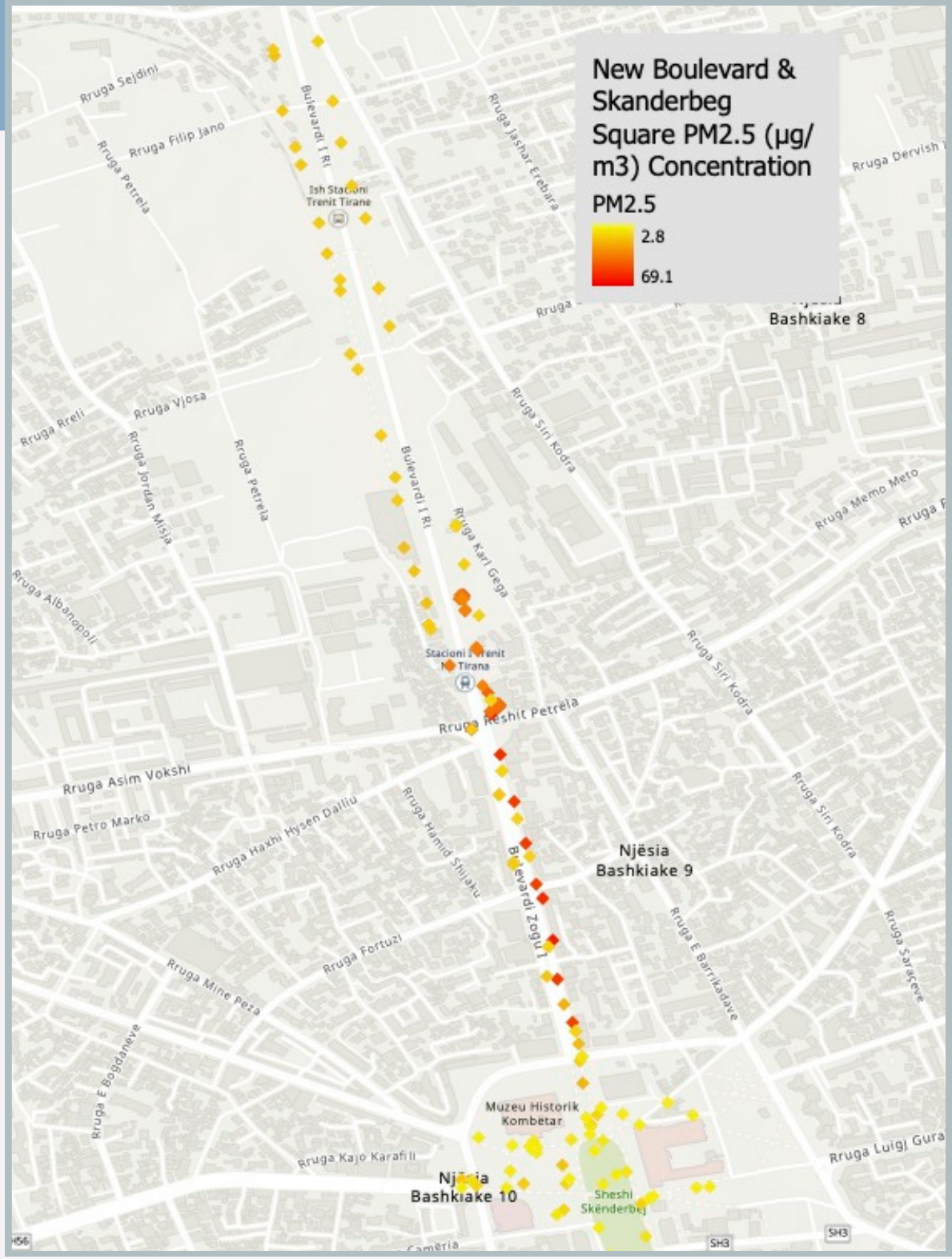


Figure 19: map of New boulevard and Skanderbeg square

High Traffic Areas

Boulevard Zogu I has higher PM2.5 levels than the New Boulevard ranging between 49.9 µg/m³ and 58.9 µg/m³ which is the highest PM2.5 data we measured in Tirana. This intersection was monitored from 4:30 PM to 5:00 PM while traffic was increasing. At the stop light, both roads had traffic congestion causing this area to have vehicle emissions at every crossroad for a pedestrian to be exposed to.

Along the New Boulevard, there are benches and an outdoor sitting area next to the major intersection. When people walk through or spend time at the New Boulevard at times of rush hour, they are exposed to prominent levels of PM2.5 emitted from the vehicles.

One of the major intersections along the New Boulevard is with Rruga Reshit Petrëla. This intersection had an average PM2.5 of 45 µg/m³. This exceeds the annual WHO recommendation and the EU regulations for PM2.5. While pedestrians are walking along this intersection and waiting at crosswalks they are being exposed to a harmful level of pollutants. Any resident living in this area who frequently visits these roads, as well as anyone who has prior health issues, is at extreme risk of health effects in this area.

Skanderbeg Square is a high foot traffic area that is an important landmark where the community gathers periodically either for events or regularly for free time. Skanderbeg Square is separated from the street, which decreases PM2.5 exposure. The average PM2.5 for Skanderbeg Square was 5.19 µg/m³, the lowest measurement being 4.7 µg/m³ and a high of 6.4 µg/m³. The average PM10 for the square (map can be found in Appendix G) was 6.63 µg/m³ which is well under the WHO PM10 recommendations of 15 µg/m³ annually. Skanderbeg Square is a high traffic pedestrian area but has the lowest levels of PM10 and PM2.5 that were measured for the high traffic areas.

Figure 20: New Boulevard

Green Spaces

How do greenspaces serve as havens in a polluted city?

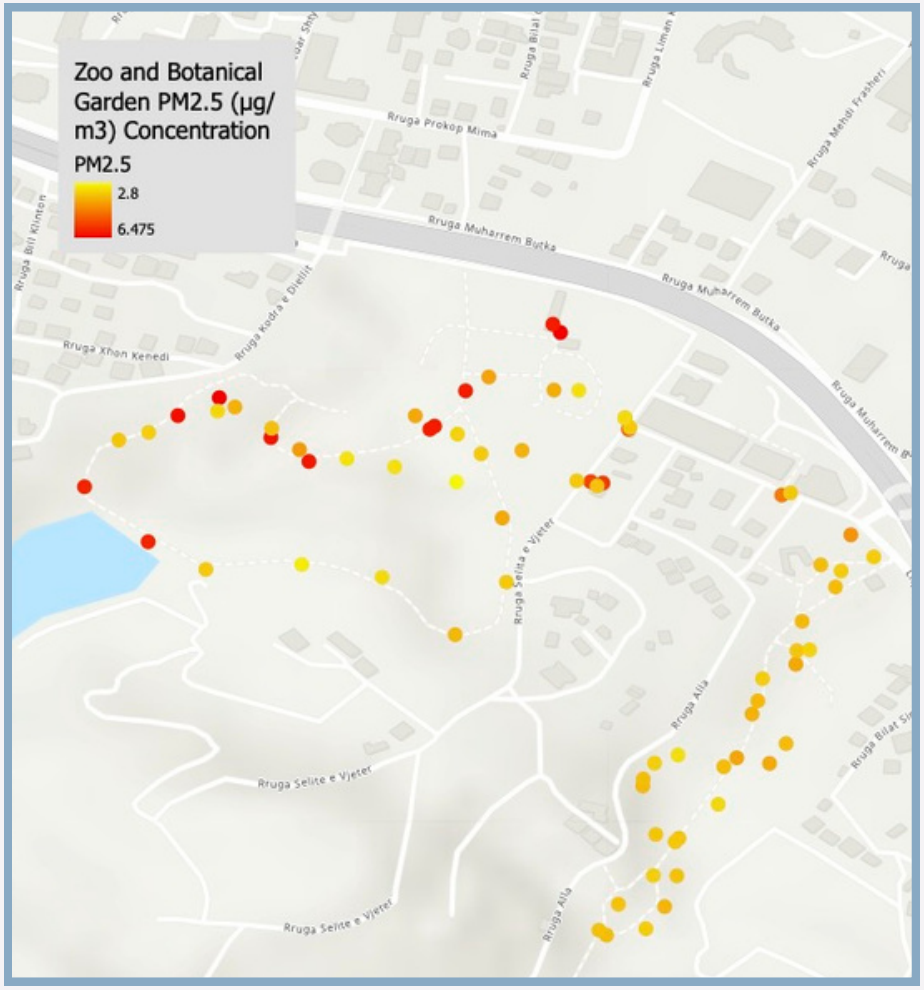


Figure 21: Map of Botanical Gardens and Tirana Zoo

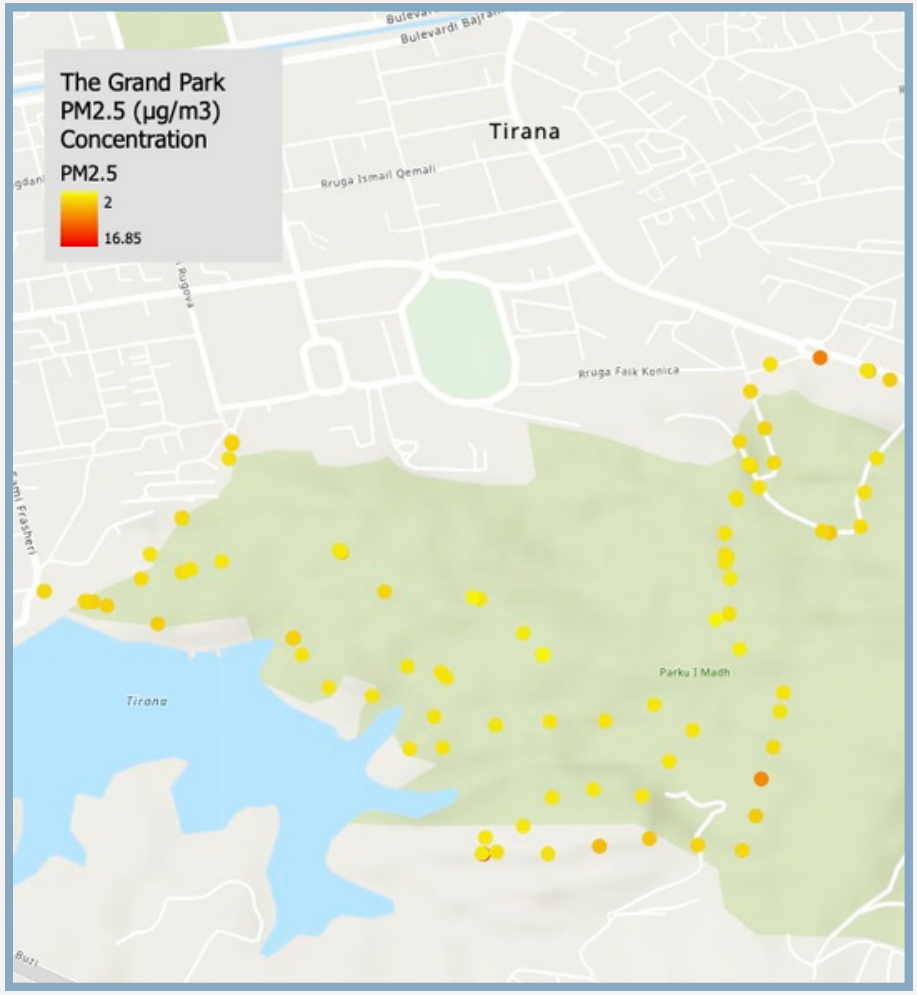


Figure 22: Map of the Grand Park

The Grand Park, the Zoo, and the Botanical Garden of Tirana all offer walking paths away from roads through areas with significant vegetation. Our monitoring in these areas has shown safe levels of particulate matter. The graph below compares these green spaces to major urban areas.

Green Spaces

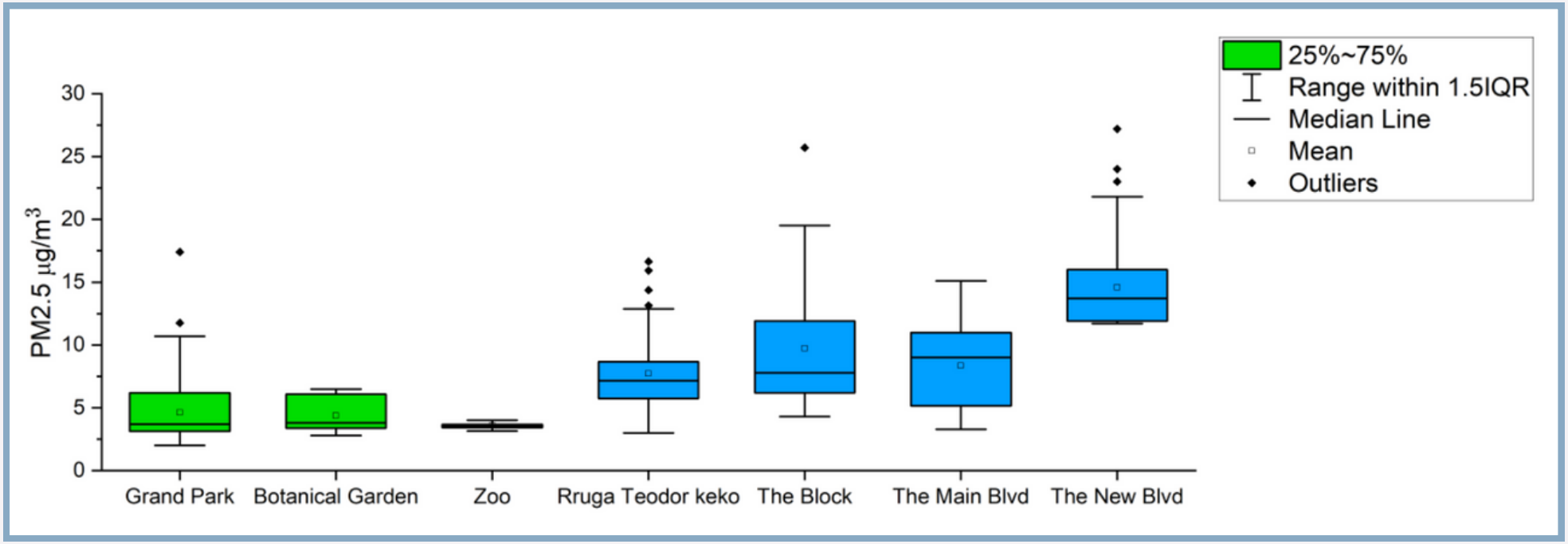


Figure 23: box of whisker plot PM2.5 levels around Tirana

Our findings above highlight the lower average levels of PM2.5 found in these green spaces around the city (see Appendix K for PM10). Green spaces may be cleaner as a result of the abundant vegetation and offering buffer distance between paths and roadways. Despite the safe averages, we found that the Grand Park is particularly susceptible to significant pollution spikes.

We measured PM2.5 levels as high as 17.4 µg/m³, which is more than three times the average in the park. One cause for this is the use of motorcycles, which is not seen in the zoo or the botanical garden. The zoo is a uniquely consistent area, with all PM2.5 measurements across four sensors reading between 3 and 4 µg/m³. This was likely due to the small size of the park. It was the only area to never exceed the annual WHO PM2.5 guideline.

Street Characteristics

How do different street characteristics affect pedestrian exposure to pollutants?

To observe the relationship between street characteristics and pollution levels, our team investigated the Block and the Main Boulevard. These two areas frequent many pedestrians going to work, to a café, and grocery shopping having several differing variables, like street size and commercial/non-commercial regions, which makes the pollutant exposure in some areas higher than others.

Our team gathered data during the morning and afternoon rush hour to see the pollutant levels in distinct parts of the day. The morning gathering session took place between 10 AM and 12 PM and the afternoon gathering session took place between 3 PM and 4:30 PM. Each session took place on separate days with weather conditions on both days partly cloudy and 1-2 days after rain.

Figure 24 shows similar PM2.5 concentrations in the morning with more disparity in the afternoon for both areas.

Our data suggests that during the entirety of our time walking in the morning, we were exposed to pollutant levels above the WHO standard.

This trend changed in the afternoon with 90% of our data points from the Block and 52% of data points from the Main Boulevard exceeding the WHO standard. The morning PM2.5 data for the Block and Main Boulevard were 10.73 µg/m³ and 10.49 µg/m³, respectively. The afternoon PM2.5 data for the Block was a similar measurement to the morning with 9.34 µg/m³, however the Main Boulevard measurement read a 5.99 µg/m³.

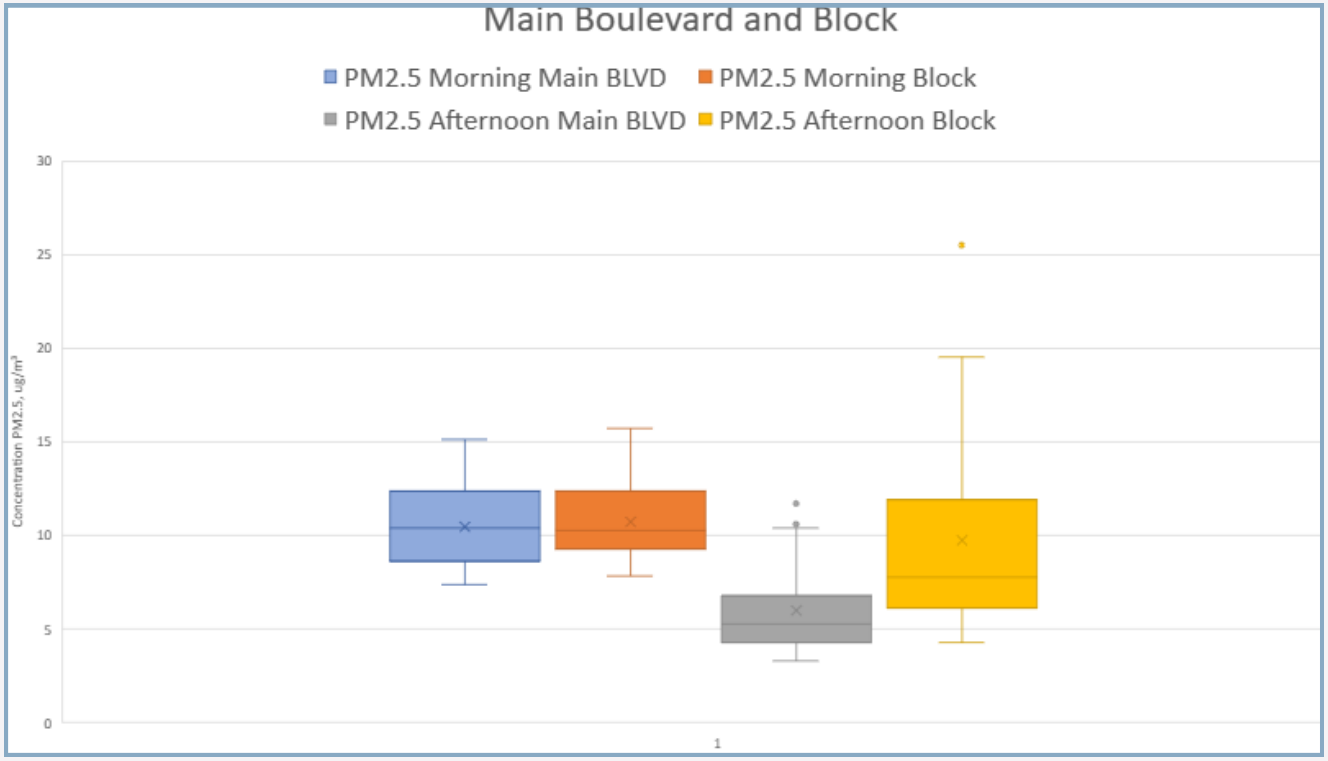


Figure 24: PM2.5 concentrations for the Block and Main Boulevard data, mornings and afternoons.

Street Characteristics

Although both averages show a decrease throughout the day, there is a more drastic difference in the Main Boulevard data compared to the Block data, which aligns with our research in trapped particulate matter. The Main Boulevard is designed with much open space for pollutants from morning traffic to dissipate, as the lengthy sidewalks have a buffer of trees and a bike lane between the car lanes. Many of the side streets in the Block are the width of a standard car and offer little space between foot traffic and vehicle pollutants. These alleyways are usually congested by vehicles, so foot traffic in this area could be exposed to the suspended PM in tight spaces.

Our analysis also shows that there was an increase in pollution levels around commercial areas. Rruga Abdyl Frasheri is a popular area of the Block with numerous businesses and restaurants. This major roadway measured an average PM2.5 level of 10.31 µg/m³. The area on the Main Boulevard near the intersection of Boulevardi Bajram Curri and the Main Boulevard is lined with cafes and restaurants. The average PM2.5 level of this area was 8.65 µg/m³. The rest of the Main Boulevard, which is mostly noncommercialized, measured lower than these two commercialized areas at 7.81 µg/m³. The data suggests that those walking through or spending a considerable amount of time in these commercialized areas could be exposed to higher pollution levels. Figure 25 depicts the locations mentioned above.

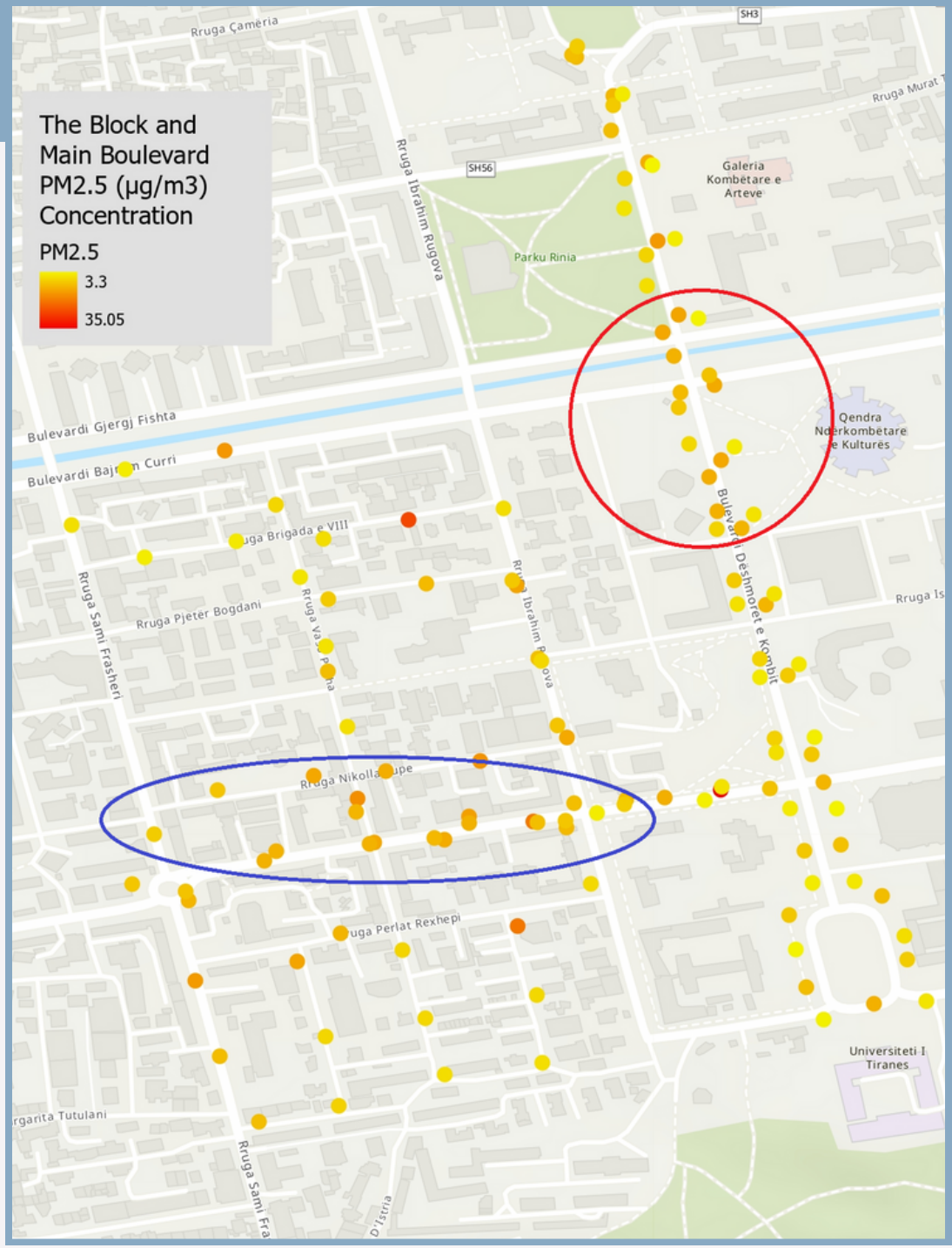


Figure 25: Morning and Afternoon data from the Block.
Blue Circle: Rruga Abdyl Frasheri
Red Circle: Intersection of Bajram Curri and the Main Boulevard

Schools

How much pollution are children exposed to on the way to and from school?

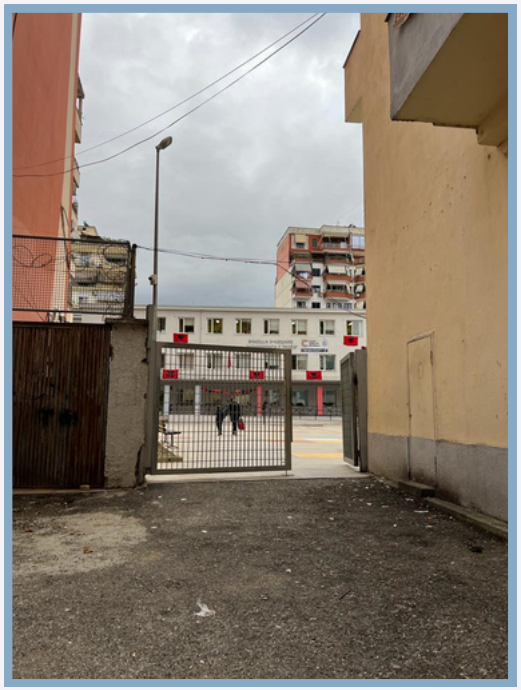


Figure 26: Shkolla 9-vjeçare konferenca e pezes

Figure 27: Shkolla 9-vjeçare "Lidhja e Prizrenit"

http://wikimapia.org/10960658/Shkolla-9-vje%C3%A7are-Lidhja-e-Prizrenit

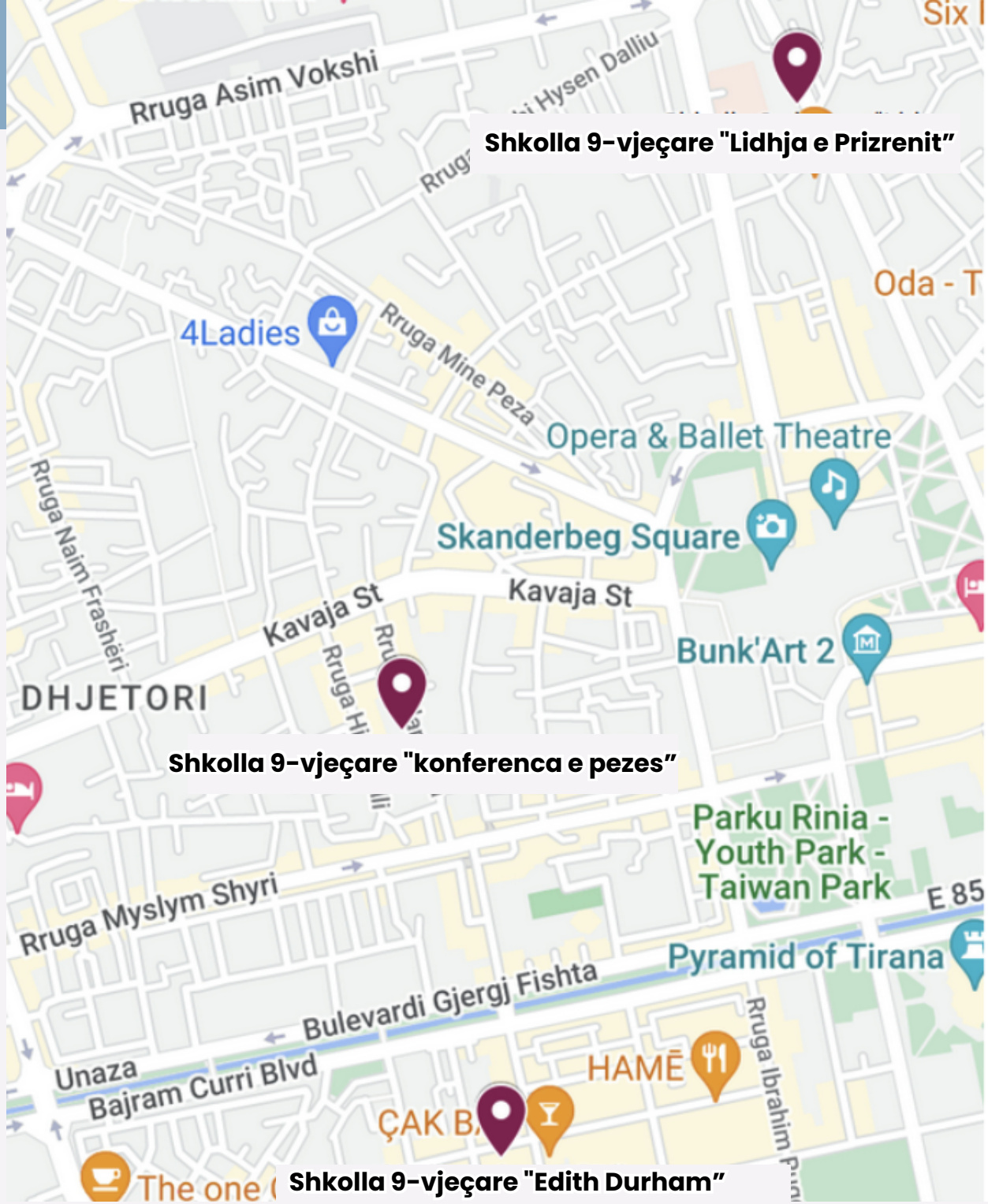


Figure 28: maps of schools monitored

Schools

How much pollution are children exposed to on the way to and from school?

Three schools were investigated: Shkolla 9-vjeçare "Lidhja e Prizrenit," Shkolla 9-vjeçare "Edith Durham," and Shkolla 9-vjeçare konferenca e pezes. Shkolla 9-vjeçare "Lidhja e Prizrenit" is positioned directly next to a construction site, a well-known source of particulate matter. Additionally, it's located on a busier street, where there were many cars idling while students were being dropped off. This school experienced the highest pollution levels, potentially due to the previously mentioned factors and the lack of rain in the three days leading up to monitoring of this school.

Figure 29: Shkolla 9-vjeçare "Edith Durham" https://external-content.duckduckgo.com/iu/?u=https%3A%2F%2Fphotos.wikimapia.org%2Fp%2F00%2F00%2F81%2F46%2F23_big.jpg&f=1&nofb=1&ipt=297d5ad5688390ff62e861b3f3ae81d1a0ced26f8a11f425f35318ef1aa8c52b&ipo=images

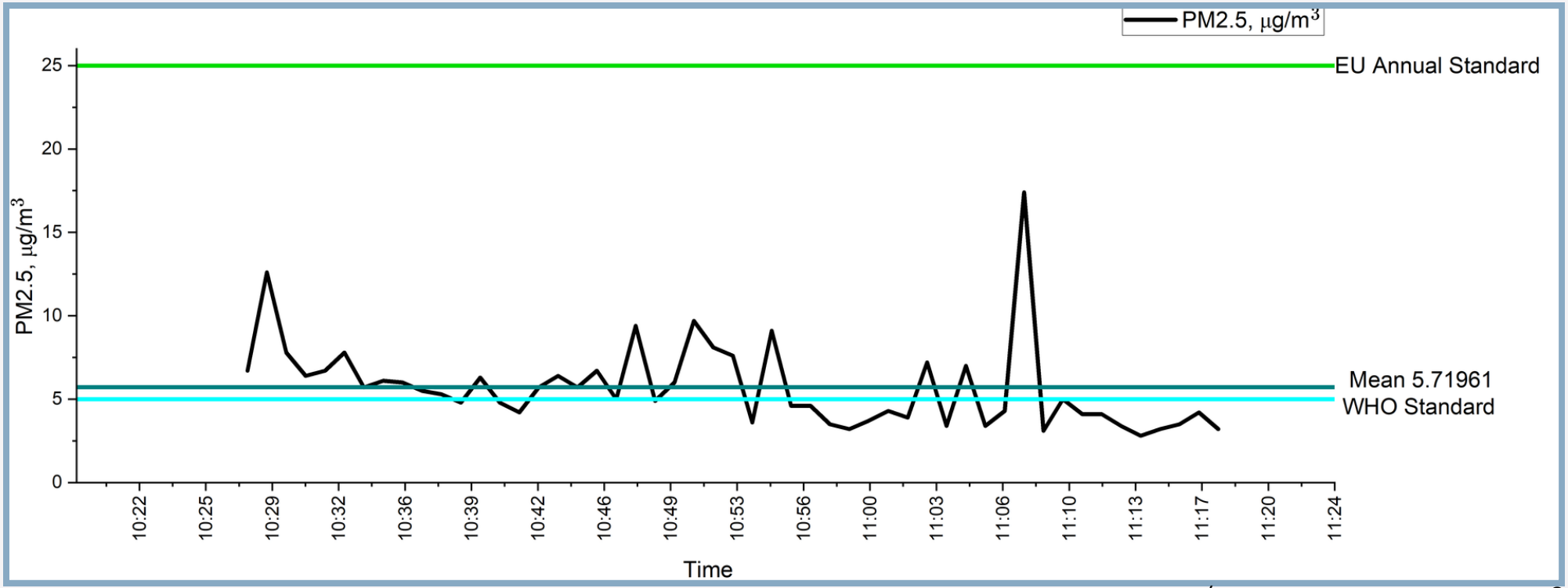


Figure 30: PM2.5 levels at Shkolla 9-vjeçare konferenca e pezes during pick up on 11/14

Schools

The data suggests that students are exposed to higher levels of pollution during drop off times than during pick up times.

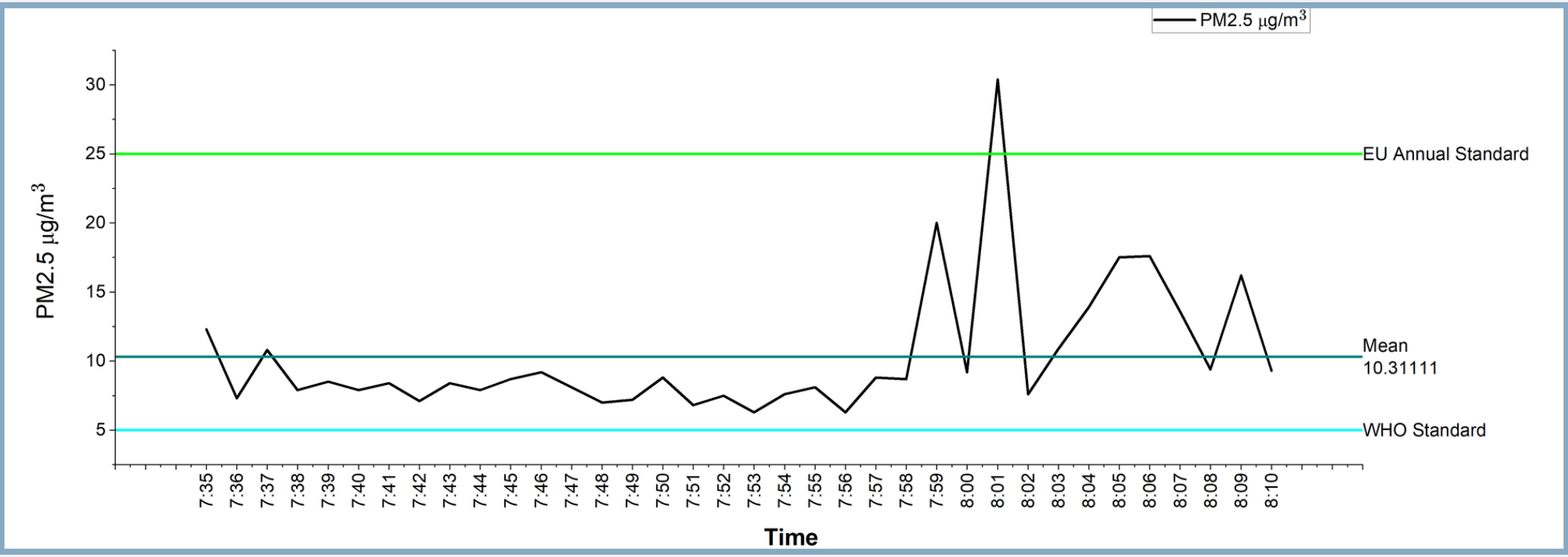


Figure 31: PM2.5 levels at Shkolla 9-vjeçare konferenca e pezes during drop off on 11/21.

Figures 30 and 31 show the PM2.5 levels over time during stationary monitoring sessions of Shkolla 9-vjeçare konferenca e pezes. Shkolla 9-vjeçare konferenca e pezes is situated in a narrow alley, which can lead to congestion due to traffic. It's important to note that the pick-up and drop off were observed on different days. Figure 30 represents the pollution levels at pick-up and Figure 31 shows the levels at drop off. The average PM2.5 levels during drop off were almost double those during pick-up. Additionally, the pollution levels at the school spike right at the drop off time (8 AM), reaching 30.4 µg/m³ while pick-up was more consistent throughout. Another school investigated, Shkolla 9-vjeçare "Edith Durham," located on a semi-busy road on the block, recorded average PM2.5 levels of 11.6 µg/m³ during drop off and 8.34 µg/m³ during pick-up. This school also saw a similar weather pattern trend to Shkolla 9-vjeçare konferenca e pezes, both experiencing rain in the 48 hours period before our monitoring period.

Schools

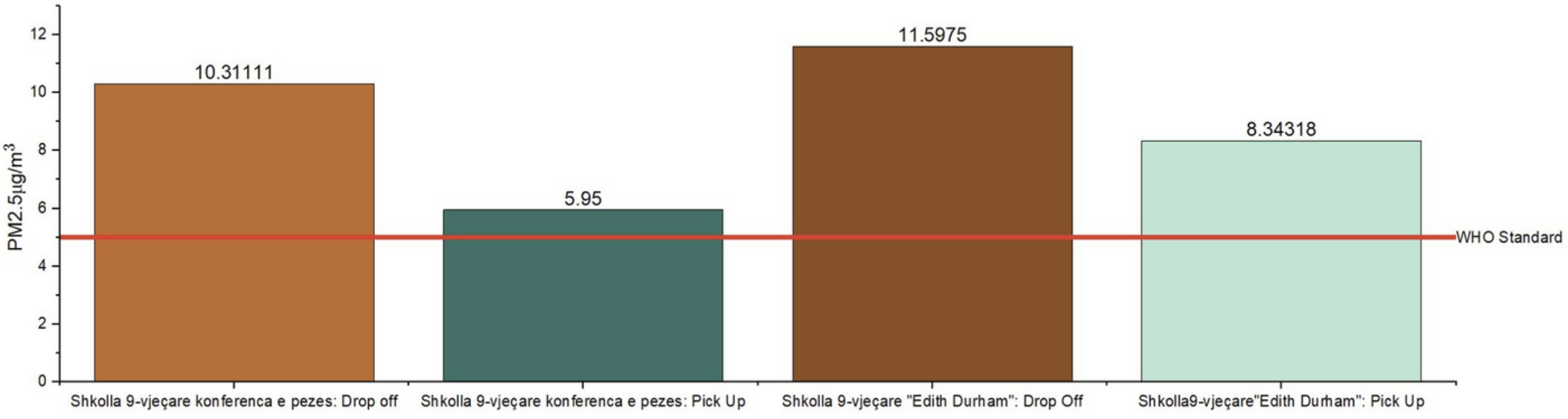


Figure 32: A summary of the average PM levels at schools:

Safe Routes to Green Spaces

Our team monitored several walking routes to investigate the exposure people face on their way to Grand Park. As seen in Figure 33, we walked four different routes through different areas of Tirana from 10 AM to 12 PM. The safest route measured was the green route with a PM2.5 value of 16.673 $\mu g/m^3$. The yellow route, orange route, and red route each had a PM2.5 value of 17.592 $\mu g/m^3$, 22.45 $\mu g/m^3$, and 23.3 $\mu g/m^3$, respectively. Despite these routes having varying levels of pollution, all the paths considerably exceeded the WHO standard.

Most of the red routes had high congestion from major commercial streets like Rruga e Kavajës, Rruga Abdi Toptani, and Rruga E Elbasanit, and a commercial area in the Toptani shopping center. The orange path went through many residential alleyways. Although these alleyways had little to no cars, there was heavy construction and earthwork being done.

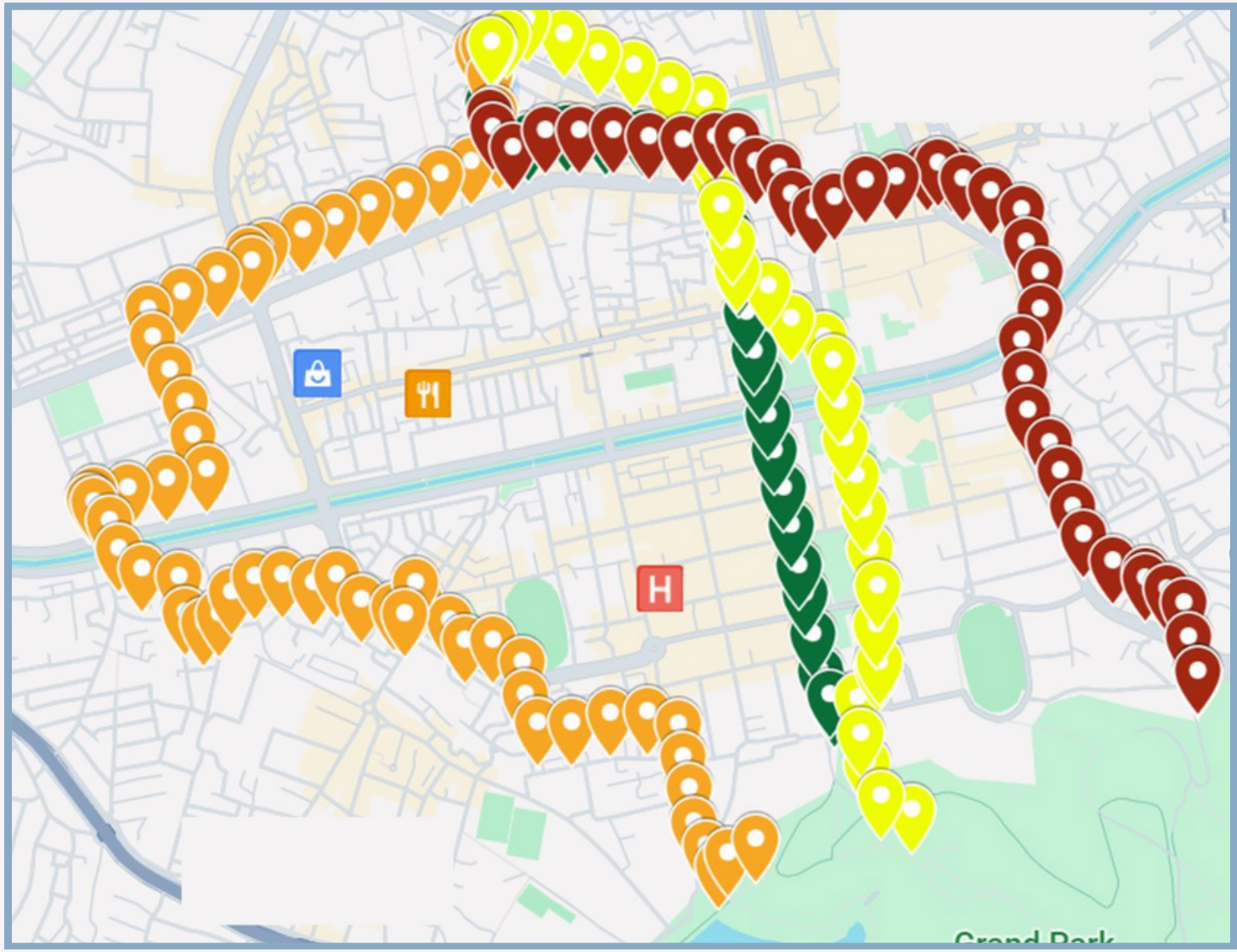


Figure 33: map of different routes to the Grand Park

Safe Routes to Green Spaces

The next two paths started on similar streets with the yellow path taking Rruga e Durrësit and the green path taking Kavaja Street. These paths converged and followed Rruga Ibrahim Rugova south till splitting at the Taiwan park. The green route then went through the Block while the yellow route followed the Main Boulevard. The Block was found the cleaner path at this time as there was a large event taking place on the Main Boulevard. These paths both reached the park with the green route being the least polluted path to the park.

The causes of pollution observed like congested alleys, heavy traffic, crowded events, and ongoing construction can influence heightened levels of particulates for those walking to green spaces. Avoiding these sources when possible is best practice for reducing exposure to pollutants.

Figure 34: picture of the Grand Park

Collaborating with Youth Activists

Collaborating with Youth Activists in Tirana

We hosted an air pollution monitoring workshop at the EDEN Center which included a hands-on walkthrough of a monitoring session. In this workshop, we showed youth the sensors and the app display of live data to the participants and explained what each number indicated. We then gave the youth Atmotube Pro microsensors and went outside to show the youth how to monitor. During our walk, we asked youth to call out sources of pollution—responses included cars, cafes, air conditioning, and dumpsters.

When we returned to the EDEN Center, we showed the participants how to upload the data they collected from a phone to a spreadsheet on a computer. Then we demonstrated how to remove extra data taken before and after the formal monitoring session based on field notes. Lastly, we uploaded the data into Google MyMaps and showed how to color each data point by the pollution level.

After demonstrating mapping, we showed how we made and used tables, graphs, and bar charts to represent different scenarios.

After the analysis demonstration, we asked the activists different questions to help them think about a monitoring project of their own that could be done once we leave. Activists were interested in monitoring at malls because people tend to spend multiple hours in a single area and hospitals because vulnerable populations are at particular risk of negative health impacts from poor air quality.

Participants indicated a desire to produce maps of the area monitored, tables with the values of PM2.5 and PM10 compared to EU and WHO standards, and charts that can better visualize the data. The activists were certain that if posters containing this kind of information were available to the public it would increase the number of activists wanting to combat pollution.

What limitations did our project have?

We encountered challenges throughout our project that may have affected our data. This season has been exceptionally rainy. Rain rids the air from pollution due to rain deposition. This rainy season in Albania affected 10 out of our 11 monitoring days, with it raining 24-48 hours before the monitoring session. Because we focused on collecting mostly mobile data, we were unable to analyze stationary data and mobile data in the same locations to draw different conclusions. Stationary data would provide a more comprehensive view of air pollution in a certain area, along with an analysis of the differing air pollution levels in certain areas. With mobile walking data we looked at a larger scope of air pollution in an area. Along with the method in which we monitored there is also a known margin of error on these censors, the sensors are capable of measuring PM2.5 and PM10 up to 1000 $\mu g/m^3$ with an error margin of ±10% above 100 $\mu g/m^3$ and an error margin of ±10 ug/m^3 below that level.

This shows that although the margin of error is exceedingly small, being only around 10%, it can still skew some of our data once we collect many different data points.

Conclusions

Potential for Future Monitoring

Potential for Future Monitoring

Tirana is experiencing severe air quality issues which impact the health of the residents. Despite this, there has been a lack of government monitoring to provide the public with crucial data. This gap in data has catalyzed a shift towards NGO and citizen science monitoring efforts.
Our analysis revealed that residents of Tirana are at risk for higher pollutant levels on intersections and can utilize green spaces to access clean air. Areas like congested alleys and commercial areas are high-pollutant-street characteristics and the exposure during school pickup times are higher than school drop off times. Our process of monitoring and analyzing was modeled in a way that would be feasible for future citizen science monitoring projects and serves as an example of the power citizens have to collect data without depending on the government or other sources.

To continue the monitoring project, WPI has provided the EDEN Center with two Atmotube Pro Microsensors. We developed a data analysis protocol using entirely free software to further reduce project costs. To reduce the technical barrier of using the monitors and analyzing the data we developed a monitoring guidebook containing all the information necessary to plan, monitor, analyze, and visualize air pollution data using the Atmotube Pro Microsensors. Since many activists have limited time to volunteer on these projects, we have devised flexible monitoring protocols and have highlighted how people with as little as one hour each week can still collect and analyze data. Lastly, while enabling activists to collect their own data has been the core of this project it leaves open the question of how that data can be used to make change both on the policy level and to protect individuals and communities.

Below we have specific areas and recommendations for ways data can be used to improve air pollution in Tirana.

Recommendations

1. Re-implementation of no-car Sundays in Tirana.
This was an initiative taken by the municipality, and how this worked is that one Sunday out of every month in Tirana there would be no pedestrian vehicles allowed on many of the main roads from 9:00 to 15:00, these roads included areas all along Boulevard "Dëshmorët e Kombit and Ismail Qemali (Tirana post 2022). The only vehicles allowed on the roads at the time were taxis, governmental vehicles, and police vehicles. Bringing this back can give at least one day a month that acts as a day where the pollution levels can diminish instead of piling up on top of each other, which is quite common during the dry seasons in Albania. This could be the start do a bigger project of no-car Sundays that can slowly continue to build other streets around the city.

Reccomendations

2. School Drop-off Routines:
Implement anti-idling policies near schools during drop-off times. Many school entrances rest on a one-way street where traffic congestion easily occurs. When idling occurs, it causes pollution near schools to increase. For schools that rest in an alleyway, having no idling zones will reduce pollutant exposure to children as they are heading into school. We suggest taking data during pick-up and drop-off times. This information can be used to talk to school administration about implementing anti-idling policies and staggered drop-off routines. This information can also be shared with parents to generate support both before and after bringing this information to school administrators.

3. Protective measures for pedestrian exposure:
We encourage a push to increase designs that protect pedestrians from air pollution. The key aspects of this are using both distance and vegetation to separate pedestrians from high traffic roads. Parks are a major example of both of these measures. One way this can be enacted is to designate some streets as pedestrian-only at certain times of day. Studies have already found significant public support for more pedestrian-only areas in Tirana (Bashkia Tiranë, 2023). Areas like sections of The Block that see heavy foot traffic in the evening could be closed to cars to protect these pedestrians. This should be discussed with the local businesses to understand the pros and cons the change would have. With support from local businesses, the subject could be taken to the Institute of People's Advocacy for detailed guidance on arranging for days to test the change and enact policy change.

For Activists

1. Participation in Air Pollution Monitoring:
We encourage activists and concerned citizens to participate in air pollution monitoring. Widespread participation is important in gathering data that can be used to influence policymaking and enforcement. For activists interested in doing air pollution monitoring with the Atmotube Pro specifically, we recommend using the monitoring guidebook we have created. It includes specific information about

QR Code to the Guidebook

using the Atmotube Pro Microsensors as well as detailed instructions for monitoring procedures and analysis techniques.

2. Community Engagement:
Contact and involve the key stakeholders and vulnerable people affected by air pollution. This collaboration can enhance support and momentum for your cause. Reaching out to bigger NGO's that have collaboration with other NGO's and have the funding and resources to help receive a grant either from the government or from the European Union. Then you must be able to pitch your project idea to the NGO's to then try and get involved or receive the proper funding to perform your project. The challenge in this is that many people are unaware of how bad air

Recommendations

pollution is making it extremely difficult to gain a following and backing without data and analysis, which needs initial funding to start. Finding the best way to disseminate the data in order to spread awareness to as many people as possible, while showing what the numbers really mean.

3. Direct Outreach:
We recommend taking air pollution information directly to those affected, like encouraging schools to adopt alternative pick-up and drop-off routines to protect children and informing individuals of ways to protect themselves from air pollution. One way to first inform parents of the exposure their children face information can be sent to schools. Schools can directly inform the parents through emails, their website, Facebook or sending the children home with informative handouts to give their adults in the family. Once the parents are informed, the schools can begin to use alternating pick-ups and drop-offs because the parents will have already received the information on why this is protecting their children.

4. Accessing Government Air Pollution Data:
For activists seeking government air pollution data, we recommend requesting the data from the National Environment Agency and Ministry of Tourism and Environment who are officially responsible for providing this data. If it fails to provide the data, submit a complaint to the Commissioner under the Right to Information. If this fails an appeal can be made to the competent administrative court. For further assistance, the Institute of People's Advocacy and the Ombudsman's office are available.

Areas for Future Research

The exploration of air quality in Tirana reveals several opportunities for future research which would provide a better understanding of the city's environmental health. Building upon our current findings, the following areas present promising opportunities for further investigation.
1. How to disseminate data specific to Albania:
Looking into how to disseminate data specifically in Tirana best for the citizens to understand. This can happen without any new data and focus on expanding on older data publications from the government or projects like the Green Lung Project to educate people.

2. The motivation of activists:
Researching what scenarios, vulnerable populations, or locations, of air quality monitoring in Tirana citizens have the most concern. Researching areas of interest of most of a population allows for more engagement and for the project to continue over a long time.

3. Expand monitoring to contrasting times of the year:
Expanding monitoring to contrasting times of the year, particularly with various weather conditions, could provide valuable insight into the air pollution levels year-round. With Tirana's developing tourism industry, further monitoring could also explore the effects of the tourism season on pollution levels. Overall, this area of research would provide a more comprehensive and dynamic understanding of air pollution.

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Appendix A: Citizen Science Case Studies

The Breathe London Project

Why Monitor? One notable example of a citizen science monitoring project is the Breathe London project. This project was driven by a concern for the public health crisis caused by air pollution in London (Breathe London). Mayor Khan emphasized the urgency of addressing this issue, which leads to thousands of premature deaths each year and adversely affects the respiratory health of the city's residents, especially children. He called for a collaborative effort between the government and the public to combat the toxic air emergency, hoping that the project's success would serve as a model for other cities facing similar challenges. This project had government support that played a crucial role in its initiation. However, the motivations of the mayor, as a concerned citizen, provide valuable insights into how individuals are inspired to start air pollution monitoring projects (Breathe London).

What was monitored and why: The Breathe London project measures several key air pollutants. These include PM10 and PM2.5 particulates, nitrogen dioxide, ozone, and sulfur dioxide. The monitoring of these pollutants is crucial for local communities, especially in urban areas like London, where exposure to high levels of air pollution is a significant public health concern. The data collected by projects like Breathe London not only helps in understanding the extent of pollution but also in informing policy decisions and public health interventions (Breathe London).

Building Membership, Community Involvement and Sustainability: Children's participation in monitoring activities significantly increased their awareness and understanding of air pollution issues. This enhanced understanding enabled them to analyze their own exposure to air pollution and contemplate ways to reduce it. Such educational outcomes are not only beneficial for the individual participants but also contribute to the broader goal of raising community-wide awareness about air pollution and increasing interest in future activism.

Validity and Impact of Citizen-Generated Data: This data has been pivotal in shaping policy decisions, including the implementation of Ultra Low Emission Zones and other pollution-reducing measures. Moreover, the project has spurred health impact studies, linking air quality to various health conditions, and encouraged behavioral changes among Londoners towards more environmentally friendly practices.

Data Dissemination and Visualization: One of the key features of the Breathe London project is its use of interactive maps. These maps display real-time air quality data across different areas of London. Users can zoom in to specific neighborhoods or streets to view detailed data on pollutants like nitrogen dioxide (NO2) and particulate matter (PM2.5). The data on these maps is represented through color coding making it easy for users to quickly identify areas with high or low levels of pollution. Breathe London also provides a comprehensive view of air quality data, including historical trends, comparisons between different areas, and breakdowns of different types of pollutants all in one place. For easier access, some of this data is also integrated into mobile apps. This allows users to check air quality in real-time on their smartphones and receive alerts when pollution levels are high. Alongside raw data, the project often includes educational resources to help interpret the data. This might involve explanations of what different pollutants are, why they are harmful, and what levels are considered safe or dangerous.

Appendix A: Citizen Science Case Studies

The Louisiana Bucket Brigade

Why Monitor? The Louisiana Bucket Brigade (LABB) is a project that partners with communities most impacted by pollution. Their motivation is helping those who have had their health impacted by the petrochemical industry. The Brigade was initially inspired by the resistance of communities in the Niger Delta region of Nigeria against the devastation caused by oil production and gas flaring, showing how citizen science projects can lead to the inspiration of new projects (Louisiana Bucket Brigade).

What was monitored and why: The Louisiana Bucket Brigade conducted monitoring a variety of air pollutants, focusing on vinyl chloride, ethylene dichloride (EDC). and benzene. They focused on these since their community, impacted by industrial activities, displayed violations of Louisiana's standards, and were considered toxic and carcinogenic. The bucket monitor is an EPA approved device. It is a bucket with a Tedlar bag inside that can collect air samples which can be tested at a lab. This allows for detecting about 100 toxic gases. The Louisiana Bucket Brigade's monitoring focuses on specific air pollutants detrimental to community health, particularly in areas adjacent to industrial facilities (Louisiana Bucket Brigade).

Building Membership, Community Involvement and Sustainability: The Louisiana Bucket Brigade has a comprehensive approach to building membership, fostering community involvement, and advancing sustainability. They prioritize empowering communities adjacent to toxic refineries and chemical plants, focusing particularly on African American neighborhoods to confront environmental injustices, bringing the community together (Louisiana Bucket Brigade).

Validity and Impact of Citizen-Generated Data: Following media attention, the Environmental Protection Agency (EPA) confirmed pollution levels higher than those detected by the bucket brigade. This led to the discovery of some facilities and the installation of new monitoring devices. By 1999, the bucket brigade concept had spread throughout Louisiana's "Cancer Alley," leading to the formal establishment of the LABB. The organization began granting funds to community groups to continue bucket monitoring (Louisiana Bucket Brigade).

Data Dissemination and Visualization: The LABB used a tool called the iWitness Pollution Map. This tool allows communities to document pollution in their neighborhoods. By calling or texting a dedicated number, residents can crowdsource pollution and report issues like bad smells, flares, and noise from neighboring petrochemical plants. The map was first deployed in 2010 during the BP Oil Disaster and has been instrumental in tracking various environmental impacts.

Appendix A: Citizen Science Case Studies

The Oslo Project

Why Monitor? This project started because people knew that pollution levels in Europe have been and will continue to be an issue unless something is done about it. This project differs from most others because they focused on youth remarkably similarly to our study. The reason they wanted to target the youth is because they believe in the importance of educating the future generation on the problems of air pollution. The project's approach was to utilize the students throughout the many primary schools all over Oslo and surrounding area (Castell 2021).

What was monitored and why: They were able to utilize a "toolbox." This toolbox contained homemade tools that could be used as sensors to measure pollutants such as PM through dust levels. This toolbox included a tool called the air meter; this tool consisted of a thick piece of paper where petroleum jelly would be spread on to (Castell 2021). You would then set this up outside for a few days and it would act as a monitor. Depending on how much dust was collected from the air meter, it corresponded to a certain level of pollution represented by an icon.

Building Membership, Community Involvement and Sustainability: This project was easy to roll out to the students because they were able to reach them through help from the government to contact the schools and the tool kits were inexpensive. Because they did not request funding, the government was helpful in aiding in contacting the schools. This enabled the project leaders to send out toolboxes to a wide network of schools (Castell 2021).

Validity and Impact of Citizen-Generated Data: This data has been pivotal in creating a map that allows you to see the pollution levels in surrounding areas and what schools need more help than others. It allowed for change to be pushed through new rules, including banning idling around schools to decrease pollution levels. There have been laws put in around driving near schools during hours when students are outside because many roads in the area kick up dirt into the air and cause pollution. This toolbox approach was also picked up and is used in school's curriculum all over Europe and helps little kids know more about pollution and make them aware of the issue at a much younger age. The aim was to get these kids involved in activism at a younger age to continue fighting for change (Castell 2021).

Data Dissemination and Visualization: The data collected by this project was mapped using ArcGIS Pro and is available to this day along with the data collected the toolbox lesson and template was disseminated through many different languages. The curriculum from this project can still be seen in primary school's science classes (Castell 2021).

Appendix B: Confidentiality Consent Script for Interviewees

Hello, my name is _____. I am a student at Worcester Polytechnic Institute from the US, and we are conducting research with the EDEN Center about air pollution in Tirana. The purpose of this research study is to look at the relationship between the air quality in Tirana and citizen science with the youth groups with our sponsor.

Your participation is completely voluntary. This means that you do not have to participate in this research unless you want to. Are you willing to answer some questions about your experiences with air quality? The discussion/interview will take approximately 10 minutes. (If yes, continue. If not, thank them for their time.)

Thank you for agreeing to participate

We will not identify you or use any information that would make it possible for anyone to identify you in our written report or presentations. If it is okay with you, could we use direct quotes from you? We would assure confidentiality in this case so you could not be identified

Do you have any questions? Do I have your permission to begin asking you questions? Do I have your permission to record this interview?

Appendix C: Expert Interview Questions: Greenlung Interview - Rodion Gjoka

Greenlung Interview: Rodion Gjoka
How did you get involved in the Greenlung project?
What was your role? (From here we can assess if more technical or activist)
How did the Green Lung project come about?
How did it eventually end?
What did this project aim to do?
Who was the data focusing on (youngsters or educated/elder governmental officials)
What were the limitations of the project? Was there anything you struggled with?
Like setting up the data, distributing data, continuing the project, or bumping heads with government
What are your takeaways from the Green Lung project?
What do you feel you or the project achieved/ learned
Looking at the project, what would you have done differently?
If the project had not ended, how would you have continued?
Have you been involved in any other (environmental) projects?
Have you been involved in any other environmental projects?
We have not been able to identify other projects that use sensors to measure the pollution levels at a larger scale in Tirana. Have there been other initiatives?
What are they/ why not?
Who is monitoring the data?
How can residents access this data?
Do you have any suggestions for our project?
Where to monitor, who to interview?
Are there any publications you would recommend we investigate more to aid our research?
Who was the most engaged in this project?
Who was involved (youngsters, NGOs), who was the target?
What was the community's perspective of the Green Lung Project while it was on-going?
Was there a lot of publicity for the project? Was the publicity successful?
What are some major regulation changes that can be made to improve air quality?
What may be some challenges to making these changes?
What role do the central government and ministries play in air pollution monitoring and regulation?
Is there anything we may have missed in this session? Anything important that was not addressed by our questions.

Appendix D: Example of Compiled Fieldnotes

11/7/23 - Main Boulevard Monitoring

- We monitored the main boulevard and parts of the block today. It did not rain last night and was sunny today with no sign of rain for the past few days.
- We began monitoring at 9:25 and went down the boulevard towards the block.
- We then took a left entering the block area at 9:43, at this time streets began to get narrower and the average AQS was lower than it was in the very open boulevard with lots of air and trees.
- Then at 9:50 we entered the roundabout area of the block and continued north of the roundabout and left the area at 9:52
- Then there was a construction site we ran into at 9:54 at the AMA restaurant location, this construction was all inside an already made building because of this the AQS was not affected very much with their only being a very sharp decrease for less than 1 minute. This dropped the AQS from 85 to 62 for a very short period. We then exited the construction at 9:55 and continued walking the block.
- We then turned around on the block and walked back in the same direction we came.
- We then passed a gas station at 10:02 where for 1 minute the pollution dropped to 0. It resumed back to normal numbers at 10:03
- Then at 10:08 we returned off the block, back on the boulevard, to walk back to the square where we started.
- We finally got back to our starting place at 10:18 and ended monitoring then.

Overall, the main boulevard is filled with trees, and the bike lane acts as a buffer between the sidewalks and roads. Because of this, air pollution data wavered with an AQS of 85-90, which is relatively good. As we made our way into the block, the AQS dropped down to around 80 until the end of the roundabout, and once we made our way to the inner roads, the AQS dropped significantly, to about 50-70.
One data altering factor was we walked past a gas station which tanked our data to 0. There was nothing else besides this and the daily data altering factors (like smoking etc.)

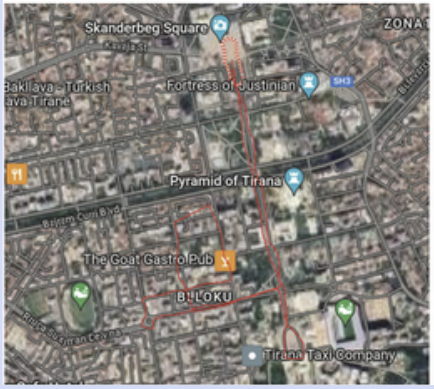

Figure 35: A Screenshot example of compiled fieldnotes

Appendix E: Data from the New Boulevard

Location: New Boulevard			
Date:	**Last Rainfall**	**PM2.5 Data (µg/m³)**	**PM10 Data (ug/m³)**
November 7th	1-2 Days Prior	13.71206897	15.43333333
November 20th	3 Days Prior	42.45238095	43.77857143

Table 4: Data comparing 24-48 hours without rain to 72 hours without rain.

Appendix F: Rruga Teodor Keko PM10 Concentration

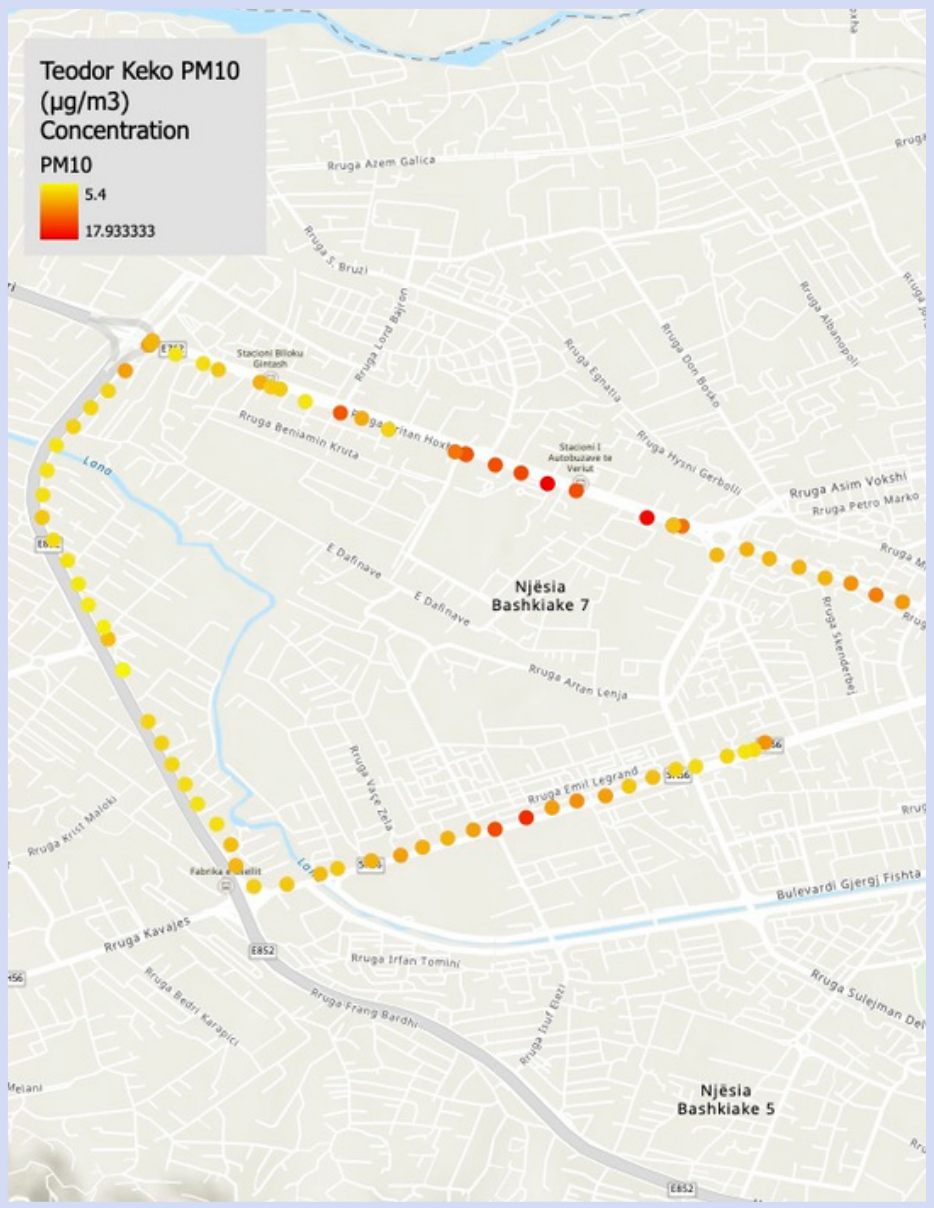

Figure 36: PM10 Concentrations along Rruga Teodor Keko

Appendix G: New Boulevard and Skanderbeg Square PM10

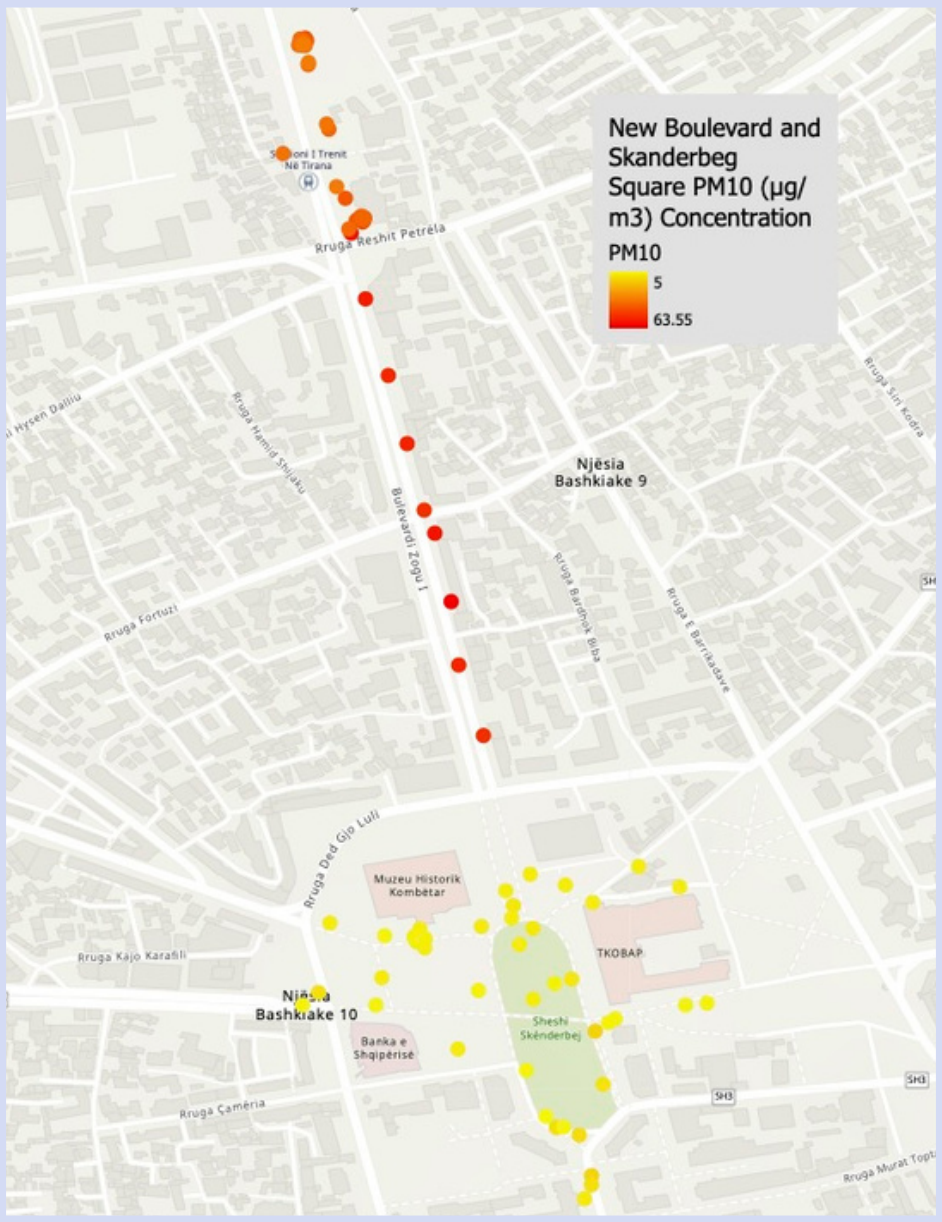

Figure 37: PM10 Concentrations along New Boulevard and Skanderbeg Square

Appendix H: Stationary Monitoring Graphs at Bus Stops

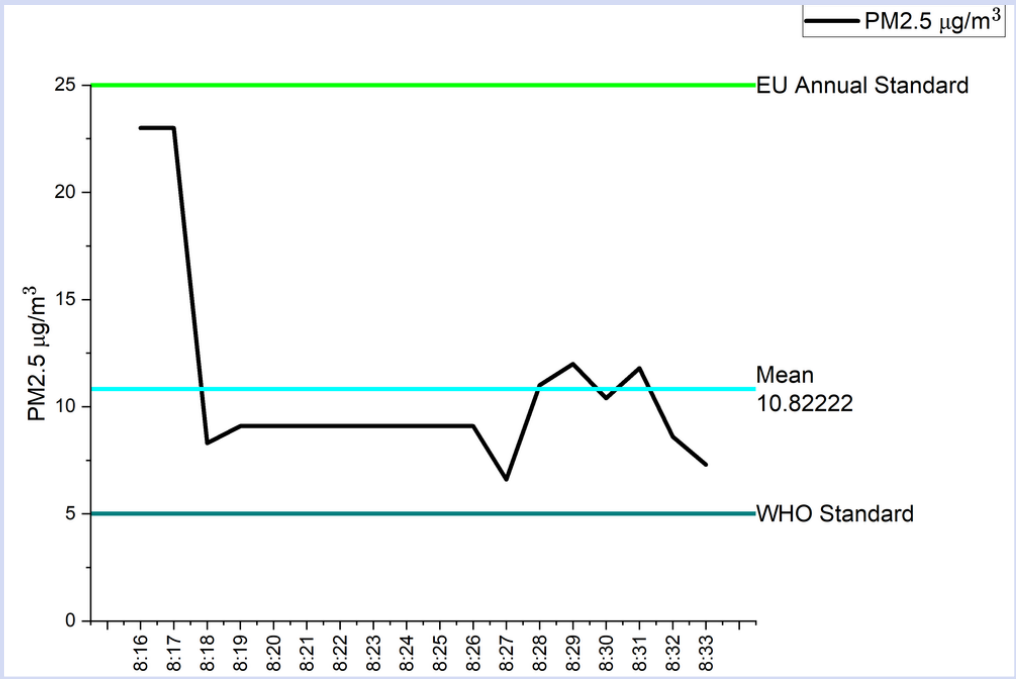

Figure 38: PM2.5 levels at a bus stop

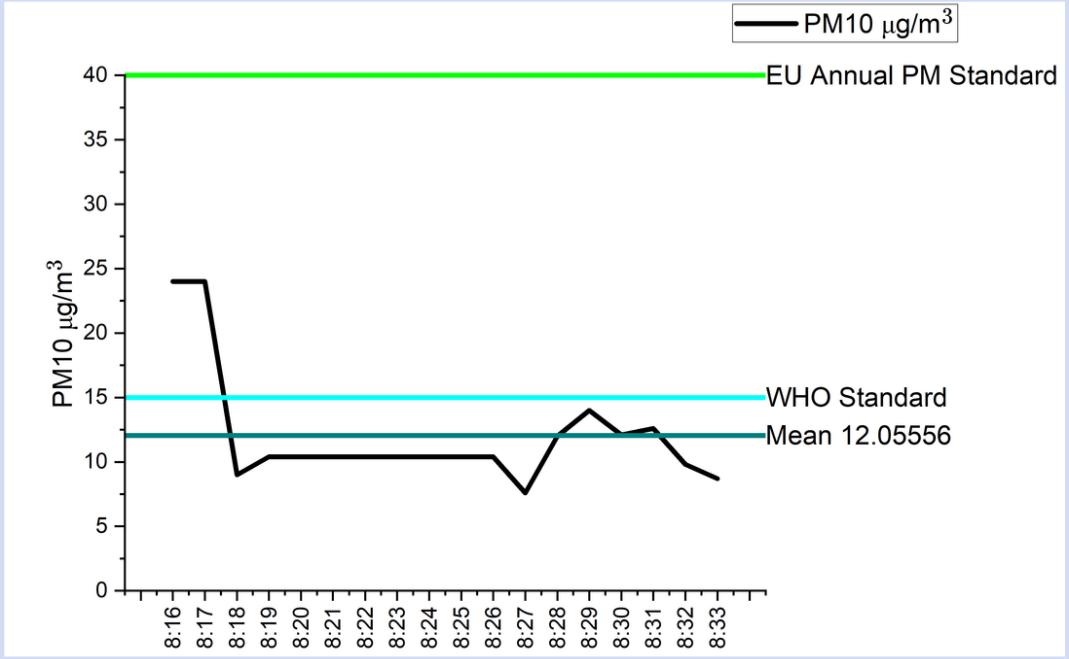

Figure 39: PM10 levels at a bus stop

Appendix H: Stationary Monitoring Graphs at Schools

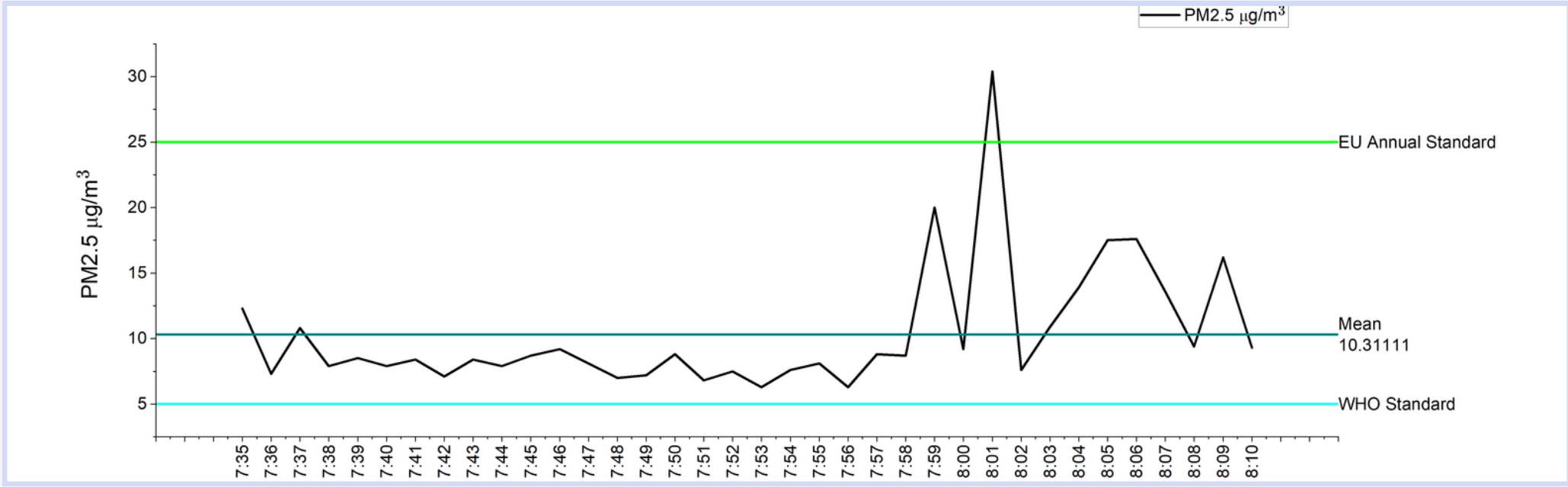

Figure 40: PM2.5 levels at Shkolla 9-vjeçare konferenca e pezes during drop off on 11/21.

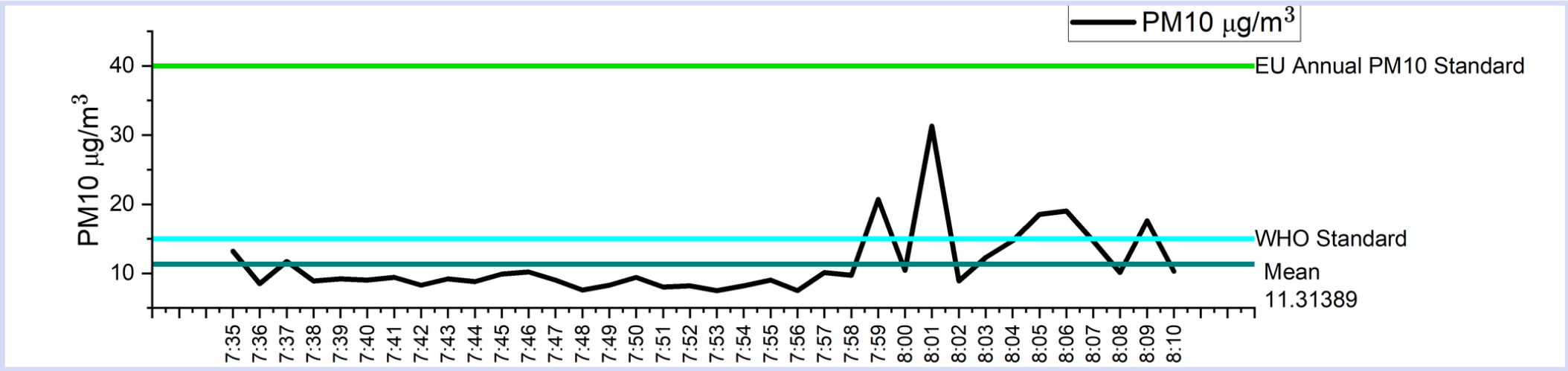

Figure 41: PM10 levels at Shkolla 9-vjeçare konferenca e pezes during drop off on 11/21.

Appendix H: Stationary Monitoring Graphs at Schools Cont.

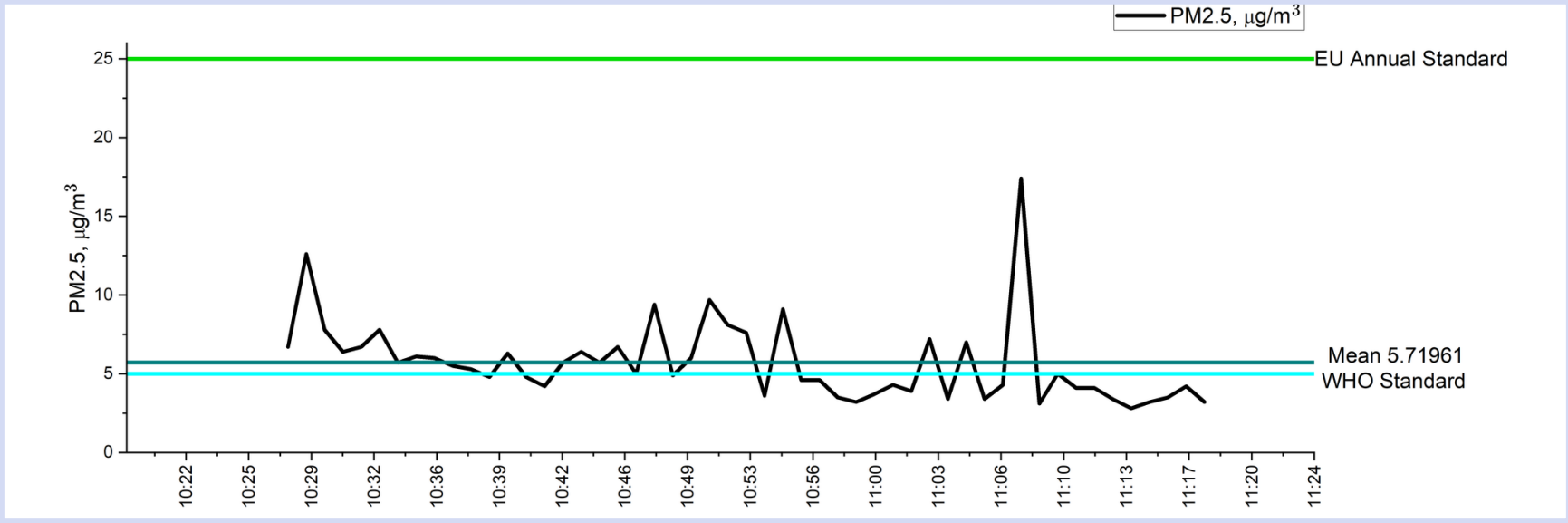

Figure 42: PM2.5 levels at Shkolla 9-vjeçare konferenca e pezes during pick up on 11/14.

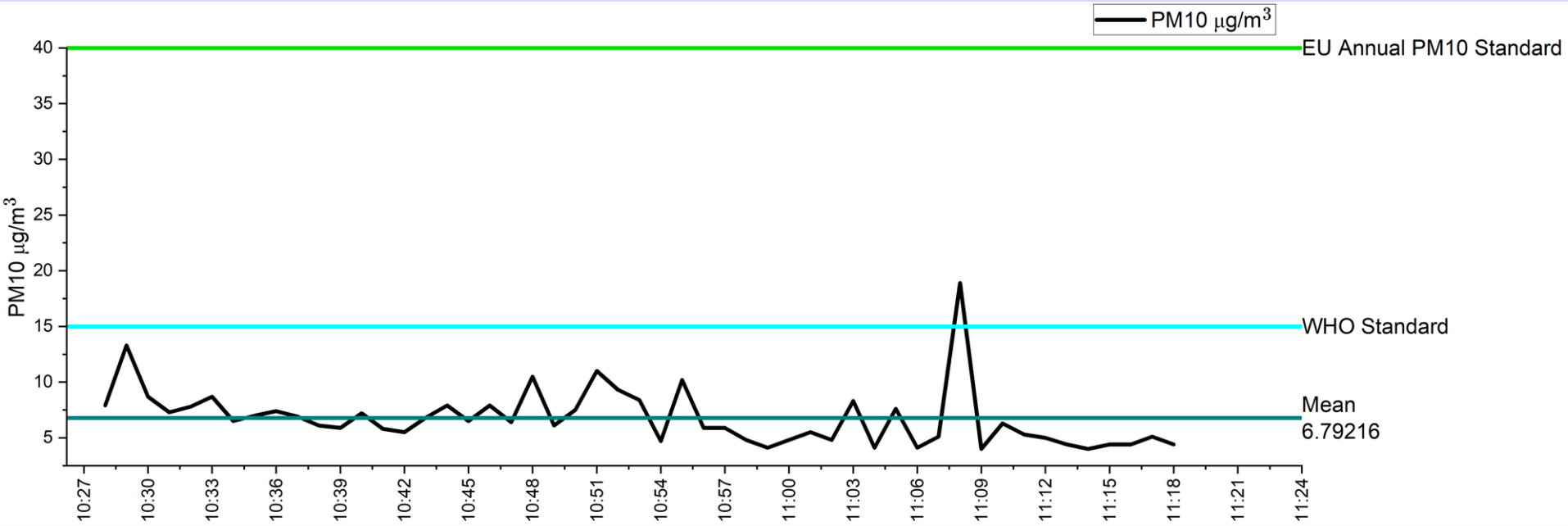

Figure 43: PM10 levels at Shkolla 9-vjeçare konferenca e pezes during pick up on 11/14.

Appendix H: Stationary Monitoring Graphs at Schools Cont.

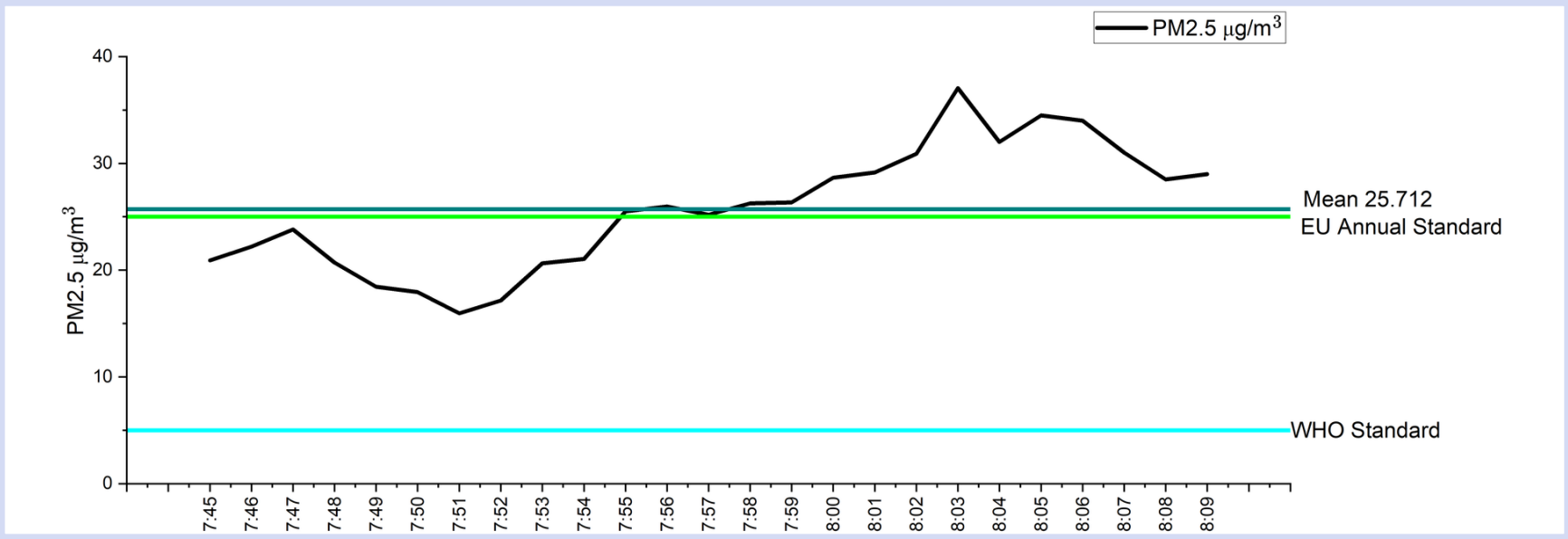

Figure 44: PM2.5 levels at Shkolla 9-vjeçare "Lidhja e Prizrenit" during pick up on 11/21.

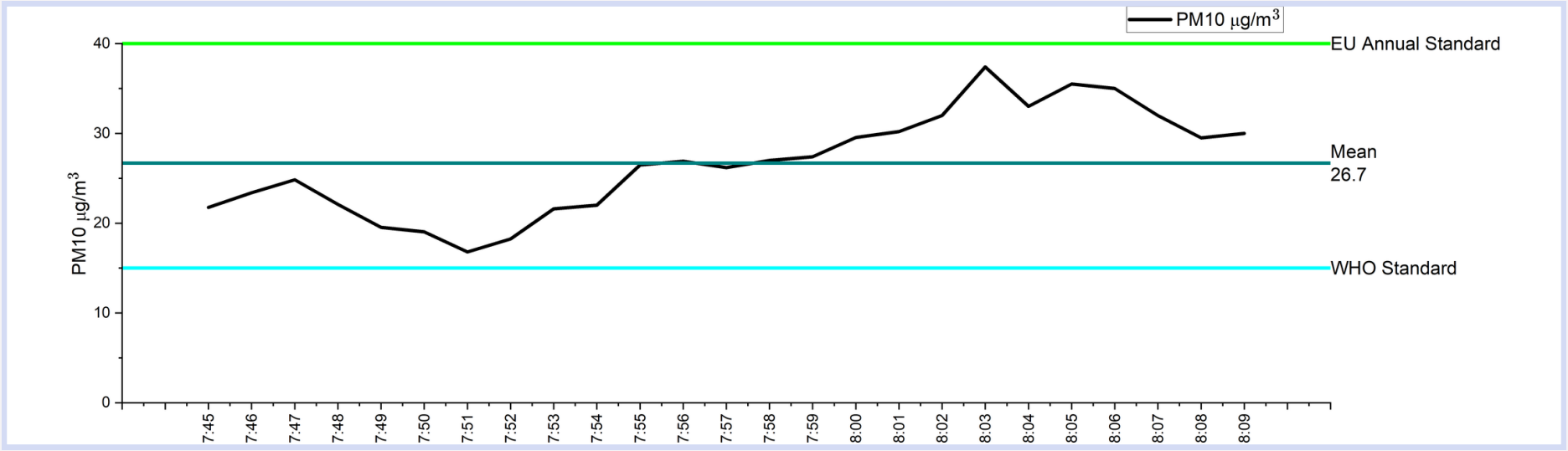

Figure 45: PM10 levels at Shkolla 9-vjeçare "Lidhja e Prizrenit" during pick up on 11/21.

Appendix H: Stationary Monitoring Graphs at Schools Cont.

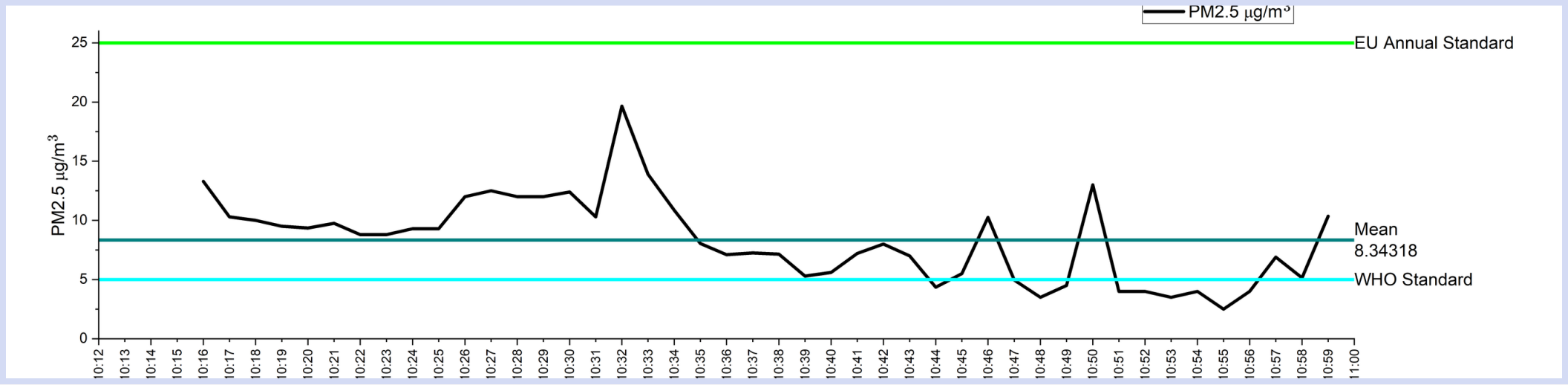

Figure 46: PM2.5 levels at Shkolla 9-vjeçare "Edith Durham" during pick up on 11/14.

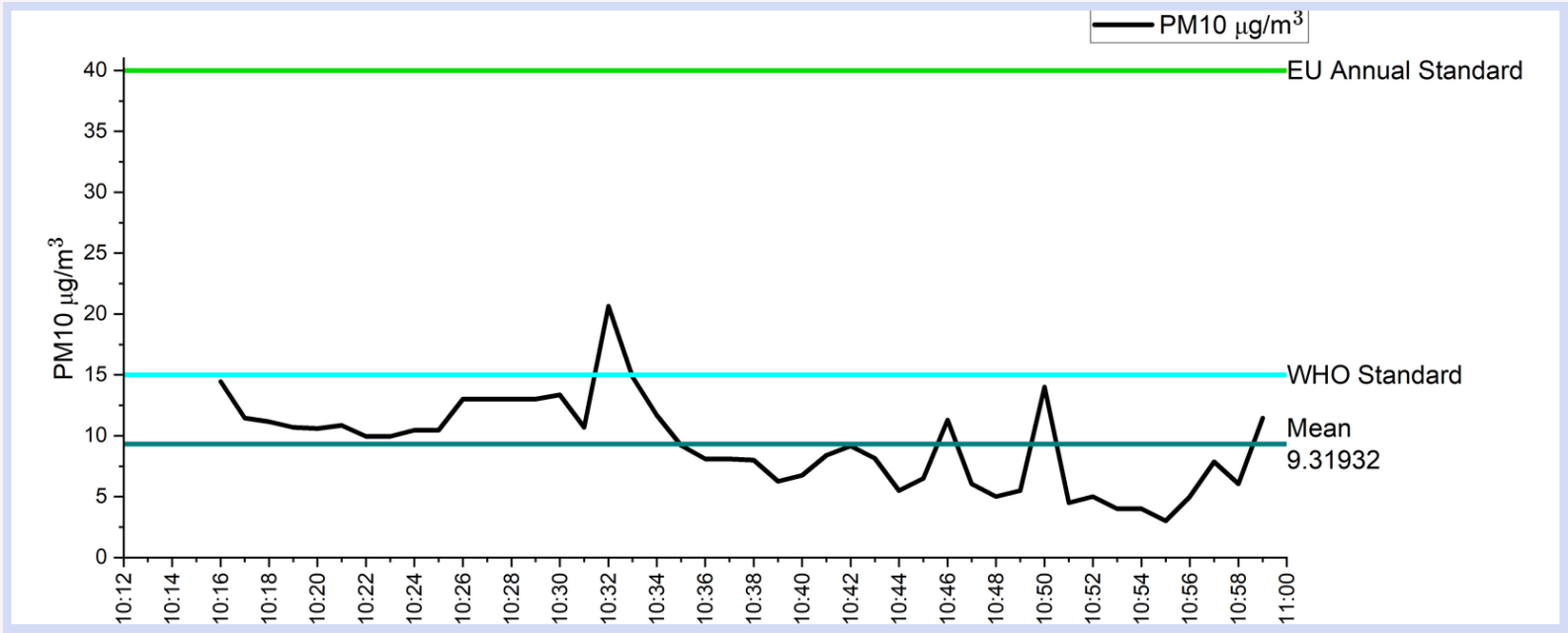

Figure 47: PM10 levels at Shkolla 9-vjeçare "Edith Durham" during pick up on 11/14.

Appendix H: Stationary Monitoring Graphs at Schools Cont.

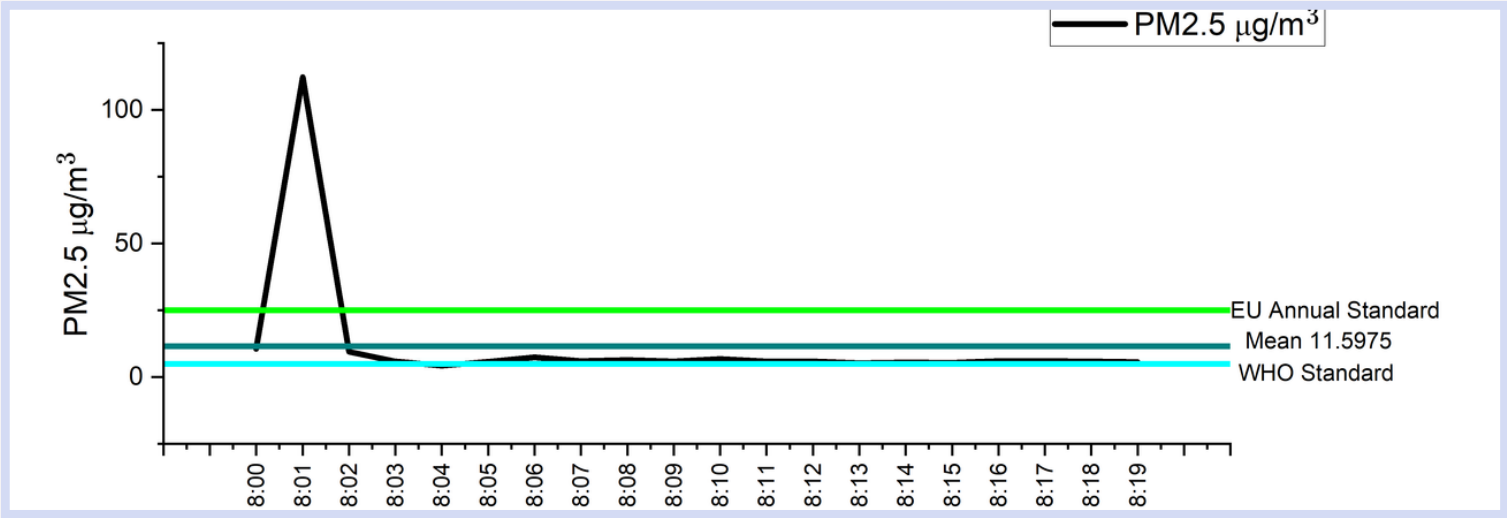

Figure 48: PM2.5 levels at Shkolla 9-vjeçare "Edith Durham" during drop off on 11/20.

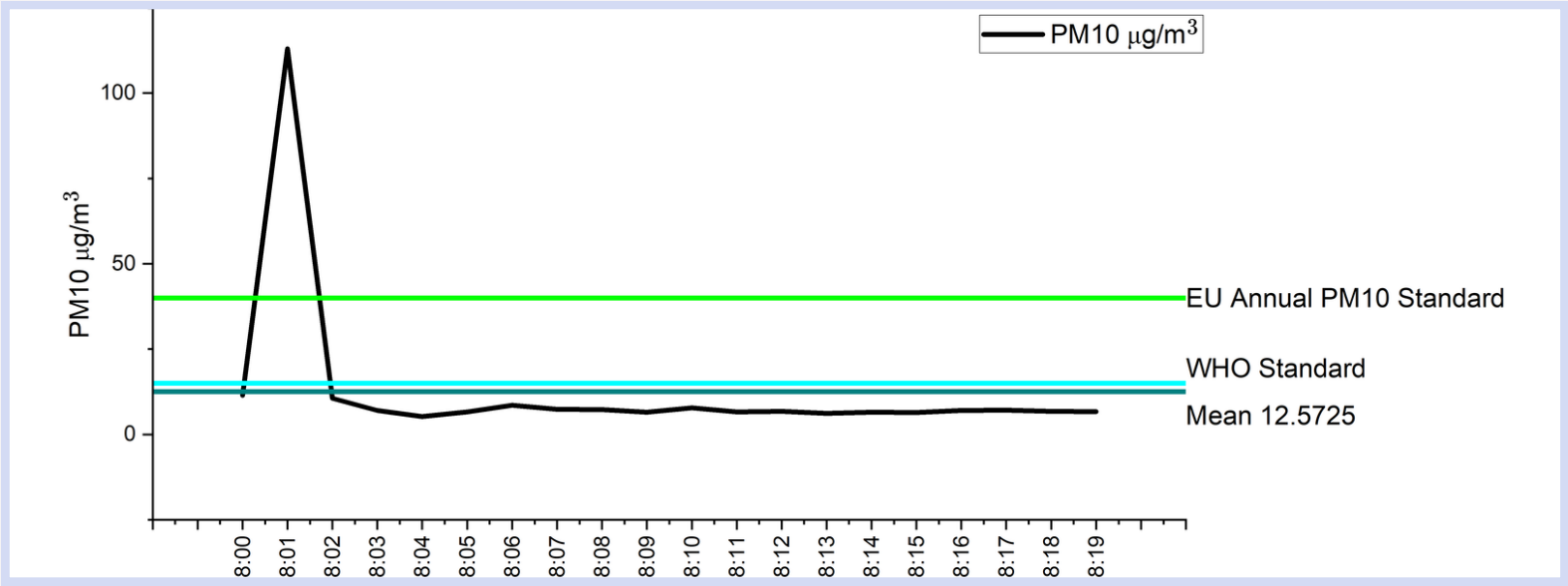

Figure 49: PM10 levels at Shkolla 9-vjeçare "Edith Durham" during drop off on 11/20.

Appendix I: PM10 map of routes.

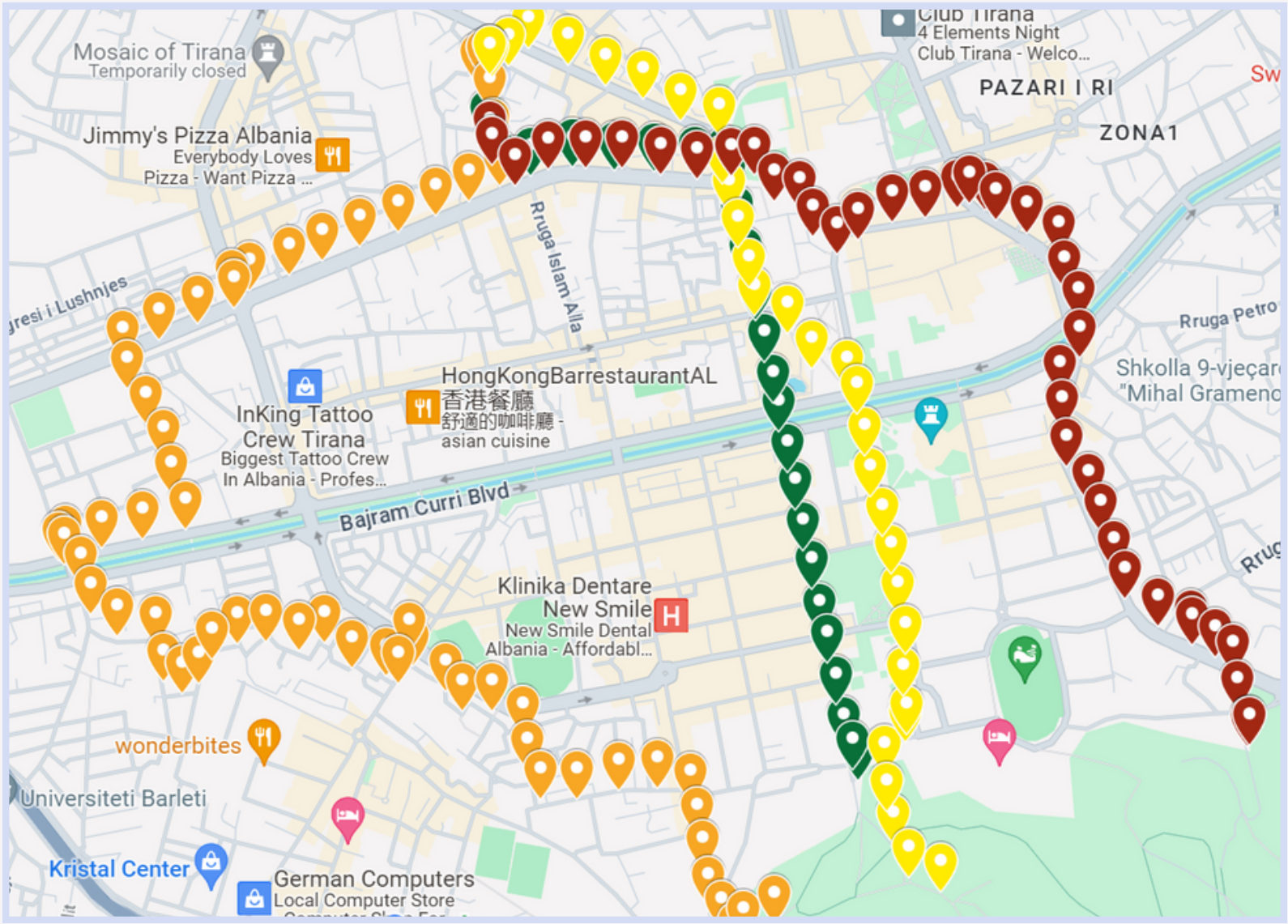

Figure 50: A map of PM10 levels on the routes to the Grand Park

Appendix J: Workshop Discussion Questions

If you had the resources, where in Tirana would you prioritize for monitoring air quality?

What locations would you be interested in seeing the data for?

Why does monitoring in this place matter?

Who is affected by pollution here?

How would you monitor this place?

How could you show that data and who would you present the data to?

What can you do with this data to make changes?

What are some problems you may face as an activist?

What are some reasons someone might choose not to participate in activism?

What role does hope play in motivating activism?

How can data empower you?

Appendix K: PM10 Plot and map for green space and high traffic areas

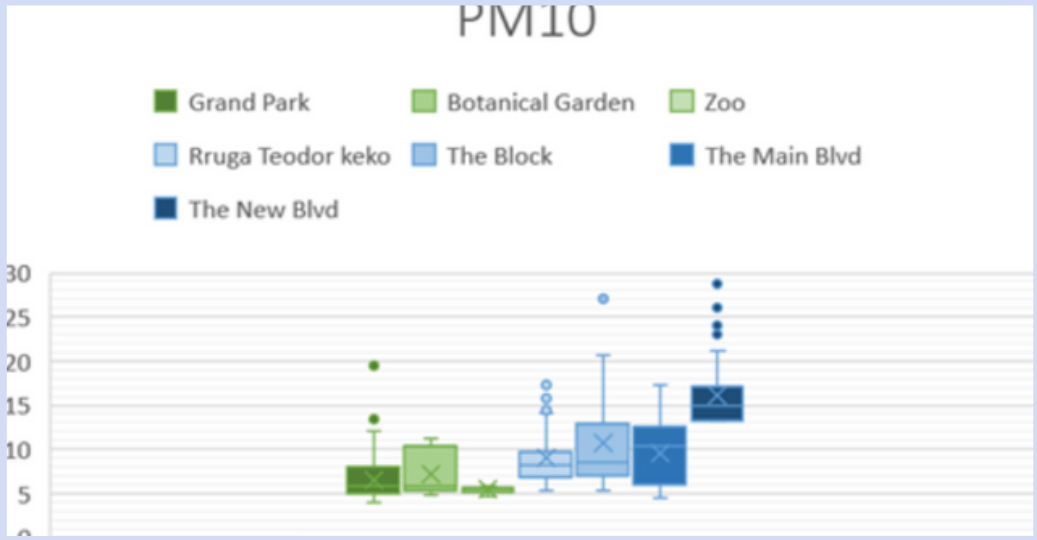

Figure 51: Box and whisker plot showing the PM10 data from the urban green spaces (green) and high traffic areas (blue)

We did not measure any points exceeding the EU standard for annual PM10 exposure, however the most polluted parts of the high traffic areas and the highest reading from the Grand Park exceeded the WHO PM10 standard of 15 µg/m³.

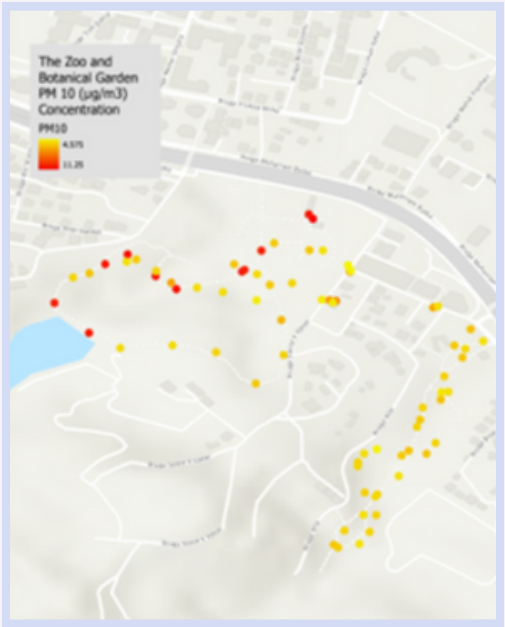

Figure 52: Map of PM10 in the zoo and botanical garden

Figure 53: Map of PM10 in the Grand Park