# Data-Driven Assessment of PM2.5 Levels in Smart City Environments: Walailak University vs Bangkok

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## Abstract

Fine particulate matter is an air pollutant that is a concern for people's health when levels in the air are high. Bangkok, Thailand, is visited by many tourists annually and is the country's capital city. This research paper aims to investigate and compare the levels of PM2.5 air temperature and relative humidity levels in the capital city and university using Davis AirLink to provide a more granular understanding of air quality in these two distinct environments: (1) Bangkok, Thailand, and (2) Walailak University, Nakhon Si Thammarat. Our results showed that PM 2.5 levels in Bangkok were higher than PM 2.5 measurements at Walailak University, and PM2.5 at these two sites had positive linear regression in all sites.

**Keywords:** Particulate Matter; PM 2.5 GLOBE Protocol, Air Temperature; Relative Humidity;

## 1. Introduction

Air pollution is among the most critical environmental issues affecting urban and rural communities worldwide. Among the pollutants, fine particulate matter with a diameter of 2.5 micrometers or smaller is of particular concern due to its significant impact on human health and the environment. These particles, small enough to penetrate deep into the respiratory system, have been linked to respiratory and cardiovascular diseases, reduced visibility, and climate change, including asthma, lung cancer, heart attacks, and strokes (Vu et al., 2020; Liu et al., 2021; Southerland et al., 2022). Monitoring and understanding the spatial and temporal patterns of PM2.5 concentrations in urban areas is crucial for urban planning, environmental policy, and public health. Monitoring PM2.5 levels is essential for understanding air quality and implementing effective mitigation strategies.

The Davis AirLink system, a valuable tool in urban areas with high pollution levels due to dense populations, transportation, and industrial activities, played a pivotal role in this study. By comparing PM2.5 concentrations in urban environments like Bangkok and rural settings like Walailak University, we underscored the impact of human activities on air quality and the importance of sustainable practices.

This research aims to study and compare PM2.5 levels, air temperature, and relative humidity across two distinct environments: (1) Walailak University in Nakhon Si Thammarat and (2) Bangkok. By leveraging the Davis AirLink system, the study seeks to analyze spatial variations in PM2.5 concentrations, evaluate the system's performance in diverse environments, and provide actionable recommendations for improving air quality in urban and rural contexts. The findings will further emphasize the need for a comprehensive air quality monitoring network to safeguard public health and promote environmental sustainability.

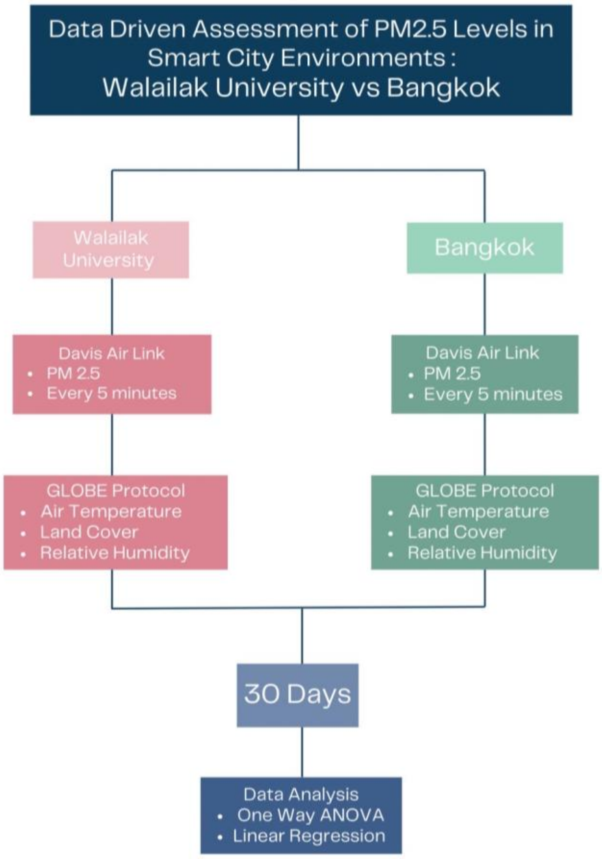


**Figure 1.1** Experimental Design

## 2. Materials and Methods

### 2.1 Study Sites

Field surveys were carried out at two locations in Thailand: (1) Walailak University in Nakhon Si Thammarat Province (8.642305°N, 99.89164°E) and (2) Bangkok (13.767114°N, 100.449311°E). Davis AirLink PM2.5 sensors were deployed at both sites to facilitate comparative measurements of PM2.5 concentrations between the two locations.


(a) (b)

**Figure 2.1** Map of Thailand. (a) Map of Walailak University, Nakhon Si Thammarat and (b) Map of Bangkok

## 2.2 Davis AirLink

We obtained the Davis Airlink sensors in real-time from 01/12/2024 to 31/12/2024. Data from the Davis Airlink were released in real-time by downloading it from the device's website, weatherlink.com. Figure 2.2 shows sample data collected from both devices.

| Date & Time | AQI | High AQI | PM 1 - ug/m | High PM 1 - ug/m | PM 2.5 - ug/m | High PM 2.5 - ug/m | PM 10 - ug/m | High PM 10 - ug/m | Temp'C | High Temp'C | Low Temp'C | Hum % | High Hum % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16/11/2024, 00:00:00 | 51.5 | 55.8 | 17.1 | 19 | 25.7 | 30 | 29.3 | 38 | 27.3 | 27.4 | 27.3 | 87.2 | 87. |
| 16/11/2024, 00:05:00 | 45.3 | 54.8 | 15.7 | 19 | 22.6 | 29 | 24.7 | 38 | 27.3 | 27.3 | 27.3 | 84.6 | 87. |
| 16/11/2024, 00:10:00 | 47 | 53.8 | 15.7 | 18 | 23.5 | 28 | 26.5 | 34 | 27.3 | 27.3 | 27.2 | 84.1 | 84. |
| 16/11/2024, 00:15:00 | 41.5 | 48 | 14.4 | 17 | 20.8 | 24 | 23.2 | 32 | 27.2 | 27.3 | 27.2 | 84 | 84. |
| 16/11/2024, 00:20:00 | 42.9 | 51.8 | 14.1 | 17 | 21.5 | 26 | 25.1 | 33 | 27.2 | 27.3 | 27.2 | 84.5 | 84. |
| 16/11/2024, 00:25:00 | 44.2 | 53.8 | 15.1 | 19 | 22.1 | 28 | 26.2 | 34 | 27.2 | 27.3 | 27.2 | 85 | 8 |
| 16/11/2024, 00:30:00 | 48.6 | 57.9 | 16.2 | 21 | 24.3 | 32 | 28.3 | 39 | 27.2 | 27.2 | 27.2 | 87.5 | 87. |
| 16/11/2024, 00:35:00 | 48.4 | 54.8 | 16.1 | 19 | 24.2 | 29 | 27.5 | 38 | 27.2 | 27.2 | 27.1 | 86.5 | 8 |
| 16/11/2024, 00:40:00 | 40.9 | 50 | 14 | 16 | 20.4 | 25 | 23.2 | 32 | 27.1 | 27.2 | 27.1 | 84.7 | 86. |
| 16/11/2024, 00:45:00 | 42 | 51.8 | 13.9 | 17 | 21 | 26 | 23.9 | 32 | 27.1 | 27.1 | 27.1 | 87.4 | 87. |
| 16/11/2024, 00:50:00 | 42.7 | 48 | 14.7 | 17 | 21.4 | 24 | 24.1 | 32 | 27.1 | 27.1 | 27.1 | 87.6 | 88. |
| 16/11/2024, 00:55:00 | 44.5 | 53.8 | 15.1 | 18 | 22.3 | 28 | 26.1 | 43 | 27.1 | 27.1 | 27 | 88.2 | 88. |
| 16/11/2024, 01:00:00 | 44.1 | 51.8 | 14.9 | 18 | 22 | 26 | 24.9 | 33 | 27 | 27.1 | 27 | 88 | 88. |
| 16/11/2024, 01:05:00 | 36.3 | 46 | 12.6 | 16 | 18.2 | 23 | 18.8 | 25 | 27 | 27 | 26.9 | 85.9 | 87. |
| 16/11/2024, 01:10:00 | 37 | 48 | 12.7 | 16 | 18.5 | 24 | 20.3 | 30 | 26.9 | 26.9 | 26.9 | 85.1 | 86. |
| 16/11/2024, 01:15:00 | 34.8 | 50 | 11.8 | 15 | 17.4 | 25 | 21.1 | 31 | 26.9 | 26.9 | 26.9 | 85.1 | 85. |
| 16/11/2024, 01:20:00 | 34.2 | 42 | 11.6 | 14 | 17.1 | 21 | 19.5 | 29 | 26.9 | 26.9 | 26.9 | 84.8 | 85. |
| 16/11/2024, 01:25:00 | 35.7 | 46 | 11.4 | 14 | 17.8 | 23 | 20.5 | 28 | 26.9 | 26.9 | 26.9 | 86.1 | 86. |
| 16/11/2024, 01:30:00 | 36.8 | 52.8 | 12.4 | 18 | 18.4 | 27 | 21.3 | 33 | 26.9 | 26.9 | 26.9 | 85 | 86. |
| 16/11/2024, 01:35:00 | 35.5 | 46 | 11.8 | 14 | 17.7 | 23 | 19.3 | 28 | 26.9 | 26.9 | 26.9 | 84.3 | 85. |
| 16/11/2024, 01:40:00 | 33.7 | 40 | 11.6 | 14 | 16.8 | 20 | 19.4 | 28 | 26.9 | 26.9 | 26.8 | 84.7 | 84. |
| 16/11/2024, 01:45:00 | 31.7 | 46 | 10.9 | 15 | 15.8 | 23 | 18.5 | 30 | 26.8 | 26.9 | 26.8 | 84.6 | 8 |
| 16/11/2024, 01:50:00 | 36.5 | 46 | 12.4 | 15 | 18.3 | 23 | 20.8 | 27 | 26.8 | 26.9 | 26.8 | 83.7 | 84. |

Figure 2.2 shows sample data collected from both devices.

## 2.3 Data Collection

Our data collection process, which commenced after installing Davis AirLink sensors at Walailak University in Nakhon Si Thammarat Province and Bangkok, was comprehensive and meticulous. From December 1 to 31, 2024, the sensors recorded high-resolution PM2.5 measurements every 5 minutes, with reference data retrieved from the DavisNet cloud service. This resulted in comprehensive 24-hour datasets, ensuring the reliability and accuracy of our results.

The field campaign was designed to analyze atmospheric PM 2.5 concentrations across different environmental contexts. Walailak University, characterized by low traffic and a low population density, represented a rural setting, while Bangkok, a high-traffic and densely populated urban area, served as a contrasting environment. This strategic placement allowed the sensors to operate under varying conditions, enabling the evaluation of their performance and reliability.

The 30-day monitoring period at both locations was a key aspect of our study, providing ample time to assess the accuracy and ecological dependability of the Davis AirLink system. This extended observation period allowed us to detect potential discrepancies or inconsistencies in PM2.5 measurements between the two sites, ensuring a more detailed understanding of the system's operational behavior in diverse environments. The measurements from reference stations further enhanced the evaluation, contributing to a comprehensive assessment of the system's capabilities.

## 2.4 Data Analysis

Algorithm calibration curves were generated using 30-day sensor measurement datasets from Walailak University and Bangkok. These datasets were analyzed to calibrate the sensor performance under different environmental conditions. A one-way ANOVA was conducted to evaluate variations in PM2.5 levels between the two locations. At the same time, linear regression analysis was employed to investigate the relationship between PM2.5 concentrations at Walailak University and Bangkok. This approach provided insights into the comparative behavior of PM2.5 levels and the performance consistency of the sensors across distinct environments.

### 2.5 GLOBE Observer Application: Air temperature and Relative humidity

This study employed the GLOBE Atmosphere Protocol to collect temperature and relative humidity data using two Davis weather stations (https://www.globe.gov/web/s-cool). Data collection commenced after the installation of sensors at two locations—Walailak University in Nakhon Si Thammarat Province and Bangkok, spanning from February 1-2, 2025. High-resolution measurements were recorded by the Davis AirLink sensors, with reference data retrieved from the DavisNet cloud service. The sensors captured readings every five minutes, producing comprehensive 24-hour datasets for analysis.

## 3. Results and Discussion

### 3.1 Comparison of PM 2.5 values of each location using Davis AirLink.

When comparing PM2.5 particulate matter levels between Walailak University and Bangkok, there is a significant difference in PM2.5 concentrations between the two areas (linear regression: $F_{61}$ =-14.156, P>0.001, Figure 3.1). The analysis of PM2.5 levels in these locations reveals noticeable variations in air pollution intensity. Notably, Walailak University has an average PM2.5 concentration of 1.50 ug/$m^3$, attributed to its designation as an educational zone with abundant green spaces and fewer pollution-generating activities. In contrast, Bangkok has a significantly higher average PM2.5 concentration of 31.45 ug/$m^{3,}$ likely due to heavy traffic congestion, industrial activities, and the high density of tall buildings that may trap air pollutants. Therefore, the differences in PM2.5 levels between these areas may result from varying human activities and environmental conditions.

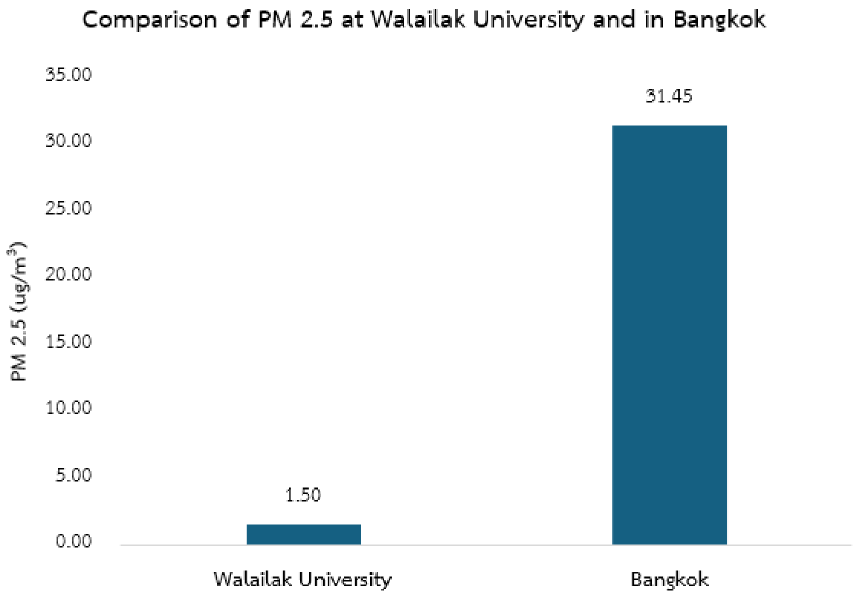


**Figure 3.1** PM2.5 Concentration between Walailak University and Bangkok sites

We compared the PM 2.5 data at Walailak University and Bangkok. The highest amount of PM 2.5 in Bangkok is on the 23rd of January 2025, while at Walailak University is on the 15th of January 2025. On the other hand, based on the above graph, it can be inferred that the lowest amount of PM2.5 in Bangkok was on the 11th of January 202,5 while at Walailak University on the 14th of December 2024

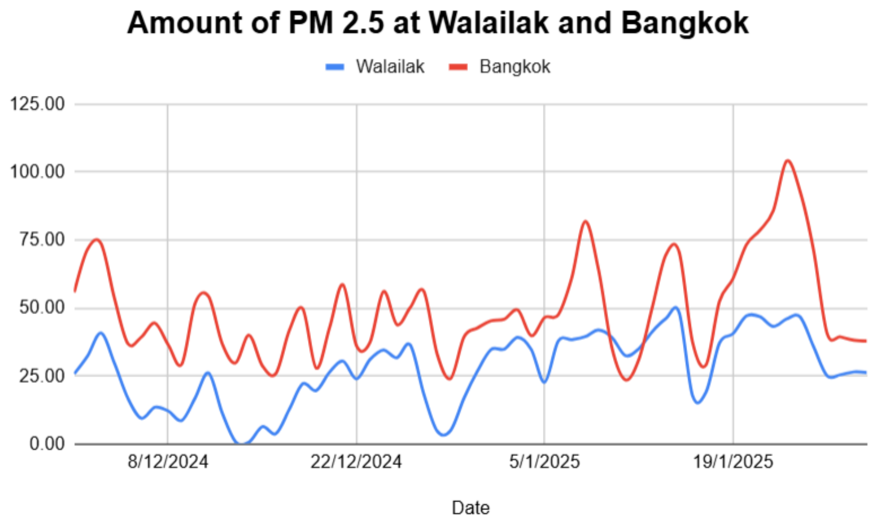


**Figure 3.2** Comparison of PM2.5 at Walailak University and Bangkok

### 3.2 Comparison of PM2.5 values and rainfall in each location

This figure shows the highest amount of PM 2.5 within the first week of December. At the same time, it can be observed that within the mentioned month, the amount of PM 2.5 ranges from 20 to 75 µg/m³, which exceeds the safe level of PM 2.5 exposure, 15 µg/m³ as recommended by the WHO organization. Despite the occurrence of rain observed during mid-December, the level of PM 2.5 in Bangkok did not significantly change, even though rain is known to purify air. This implies that several human and environmental factors, such as traffic emissions, industrial activities, and weather conditions, can cause air pollution to surge. Therefore, a mere rain cannot quickly decline the level of PM 2.5, especially when the dry season comes.

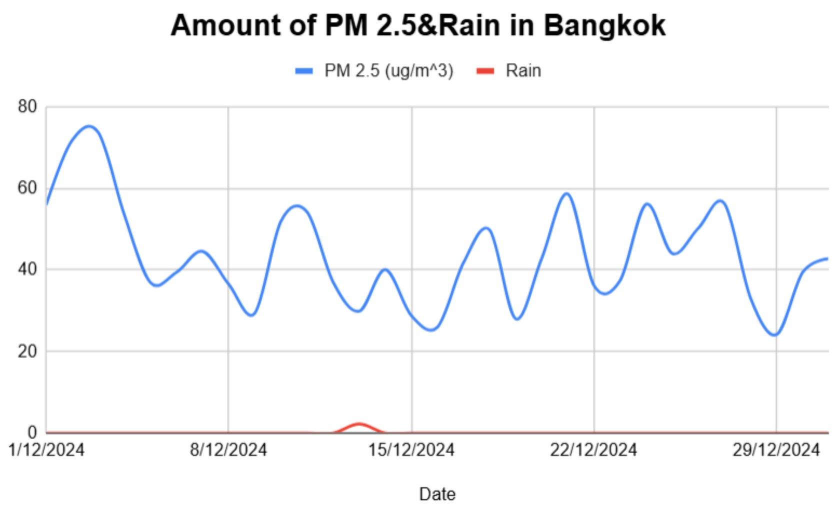


**Figure 3.3** Amount of rain and PM 2.5 in Bangkok

The graph shows PM2.5 levels and rainfall at Walailak University in December 2024. The blue line shows PM2.5 levels, which are relatively low and stable throughout the month with slight fluctuation. In contrast, the red line shows rainfall levels, which increase rapidly, especially in mid-December, when rainfall quickly reaches 450 mm. After this peak, rainfall decreases to zero, with less rainfall occurring at the beginning and end of the month. There is no direct relationship between rainfall and PM2.5 levels, as PM2.5 remains relatively constant regardless of rainfall changes.

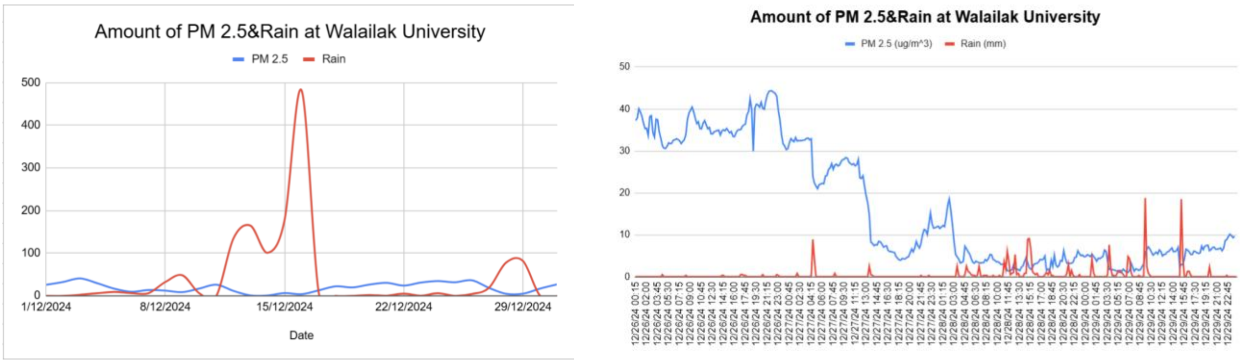


**Figure 3.4** Amount of rain and PM 2.5 in Walailak University

**GLOBE protocol**

Cloud information was collected using the globe cloud protocol because clouds can impact air quality in numerous ways. For example, clouds that act like blankets reduce the amount of sunlight hitting Earth's surface, which can impact pollutants like ground-level ozone—a key component of smog.

Clouds, floating masses of condensed water vapor, can affect the mixture of gases and particulates in the air, air and ground temperature, wind speed and direction, and humidity levels. These can vary according to the clouds' vertical and horizontal size and the time it takes to form, move, and dissipate.

Cloud data is collected using the Global Cloud Protocol. Clouds play a crucial role in weather perception and rainfall levels, which impact the concentration of PM2.5 in the atmosphere.

Rain clouds can trap dust particles and PM2.5 pollutants, helping reduce their levels when precipitation occurs. However, temperature, weather conditions, cloud cover, and wind all influence the increase or decrease of PM2.5 in different areas.

## 4. Conclusion

With the results provided, this research will provide aid regarding the current air quality situation, which could be utilized as essential information for developing programs that aim to enhance air quality. With all the graphs presented based on the data gathered it can be concluded that there is an extreme amount of PM 2.5 in Bangkok, regardless of the rain it receives. On the other hand, the abundant rain that Walailak University has received resulted in the diminishment of PM 2.5 levels. Urbanization in Bangkok is the root cause of a fluctuating level of PM 2.5, especially during the dry season.

**I would like to claim IVSS badges**

1. **I make an impact**

The report clearly describes how a local issue led to the research questions or makes connections between local and global impacts. The students must clearly explain or show how the research positively impacted their community by making recommendations or taking action based on findings. This study indicates that delicate particulate matter (PM2.5) is an air pollutant that concerns people's health. PM2.5 can travel deeply into the respiratory tract, reaching the lungs. Exposure to fine particles can cause short-term health effects such as eye, nose, throat, and lung irritation, coughing, sneezing, runny nose, and shortness of breath.

2. **I am a STEM professional.**

The report clearly describes the collaboration with a STEM professional that enhanced the research methods, contributed to improved precision, and supported more sophisticated analyses and interpretations of results. The data from the sensors were used to analyze the results. Use the graph to see how the data relate.

3. **I am a data scientist.**

The report thoroughly examines the students' proprietary data and additional data sources. Students critically evaluate the limitations of these data, draw inferences about historical, current, or future events, and leverage the data to address questions or resolve issues within the depicted system. This may involve incorporating data from other educational institutions or utilizing information from external databases. We developed a PM2.5 sensor to collect data and compare it with commercially available sensors.

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