Smart City Air Quality Assessment: Comparing PM2.5 Levels in Urban and Dam Areas

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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. Pasak Jolasid Dam in Saraburi Province, Thailand, is visited by many tourists annually and is the community's primary water supply source. This research paper aims to investigate and compare the levels of PM2.5 air temperature and relative humidity levels in the city and the dam area, using Davis AirLink to provide a more granular understanding of air quality in these three distinct environments: (1) Pasak Jolasid Dam, (2) Supattra Resort, and (3) Walailak University, Nakhon Si Thammarat. Our results showed that PM 2.5 levels around the Pasak Jolasid Dam and Supattra Resort were higher than at PM2.5 measurements at Walailak University, and PM2.5 at these three sites had positive linear regression in all three sites. PM2.5 was higher after the evening.

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.

Davis AirLink technologies with PM2.5 sensors offer a transformative approach to air quality monitoring. Davis AirLink systems enable real-time data collection, processing, and visualization, providing insights into pollution patterns and facilitating informed decision-making. Such systems are particularly useful in urban environments, where pollution levels are often elevated due to dense populations, transportation, and industrial activities. Conversely, rural areas surrounding the Pasak Jolasid Dam typically experience lower pollution due to abundant natural vegetation and lower human activity. Comparing PM2.5 levels in urban areas to rural regions like the Pasak Jolasid Dam can help highlight the influence of human activities on air quality and underscore the importance of sustainable practices.

This research paper aims to investigate and compare the levels of PM2.5 air temperature and relative humidity levels in the city and the dam area, using Davis AirLink to provide a more granular understanding of air quality in these three distinct environments: (1) Pasak Jolasid Dam, (2) Supattra Resort, and (3) Walailak University, Nakhon Si Thammarat. By analyzing the data collected, the research aims to understand spatial variations in PM2.5 levels, assess the effectiveness of Davis AirLink PM2.5 sensors in diverse settings, and provide actionable insights for improving air quality in urban and rural regions alike. Through this comparison, the study also emphasizes the need for comprehensive air quality monitoring networks to safeguard public health and promote environmental sustainability.

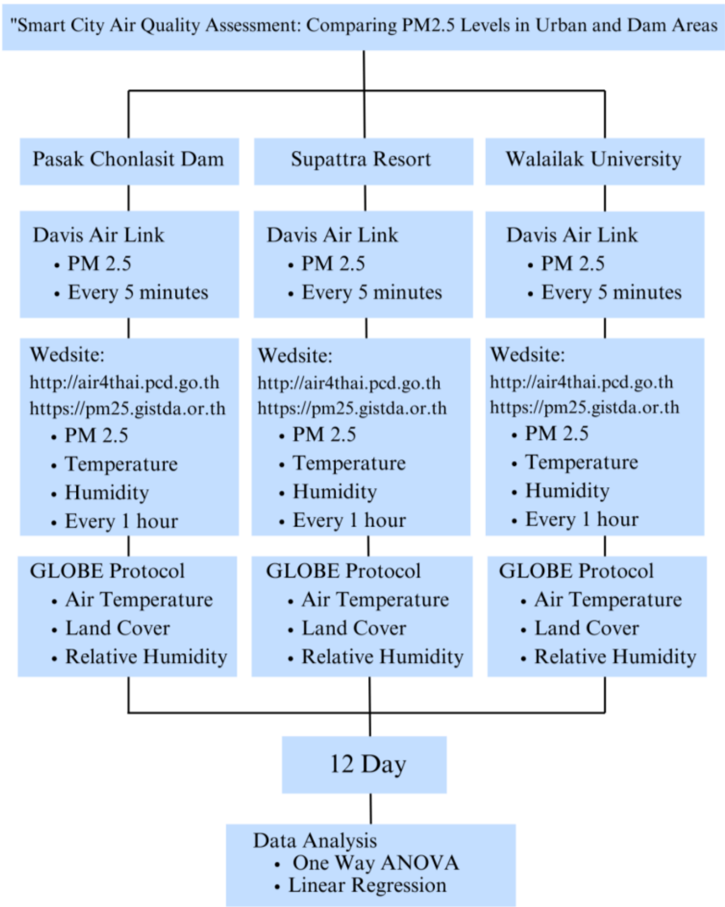


Figure 1.1 Experimental Design

2. Materials and Methods

2.1 Study Sites

We conducted field surveys at three sites in Thailand: (1) Pasak Jolasid Dam (coordinates: 14.86454°N, 101.06455°E), (2) Supattra Resort (coordinates: 14.85959°N, 101.11017°E), and (3) Walailak University, Nakhon Si Thammarat (coordinates: 8.642305°N, 99.89164°E). Davis AirLink PM2.5 sensors were used at all three field sites to enable comparative measurements of PM2.5 concentrations across the three sites.

Figure 2.1 Map of Thailand. (a) Map of Pasak Jolasid Dam, Saraburi Province and (b) Map of Supattra Resort and (c) Map of Walailak University, Nakhon Si Thammarat

2.2 Davis AirLink

The Davis Airlink sensors will be pulled in real-time from 11/16/2024 to 11/27/2024. Data from the Davis Airlink will be 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

Data collection began after installing the Davis AirLink at three locations: Pasak Jolasid Dam, Supattra Resort, and Walailak University in Nakhon Si Thammarat Province. The three locations collected data for 12 days, from November 16–27, 2024. The instrument recorded high-resolution measurements from the Davis AirLink over the same period by pulling these reference data from the DavisNet cloud service, which stores readings every 5 minutes, resulting in a 24-hour dataset. For the website data, these reference data came from the website service, which stores readings every hour, resulting in a 24-hour dataset.

The field campaign aimed to compare the concentration of PM2.5 in the atmosphere in different environments. We specifically selected two locations: the Pasak Jolasid Dam, a low-traffic and low-population area, and the Supattra Resort, a high-traffic and high-population area. This strategic placement allowed the sensors to collect data in different environments and evaluate their performance under various conditions.

The 12-day installation at the three locations provided sufficient time to assess the accuracy and ecological reliability of the Davis AirLink. We were able to detect any discrepancies or inconsistencies between the three. This allowed us to analyze the behavior of the Davis AirLink more comprehensively over the extended installation period, which allowed us to identify any deviations from the measurements from the reference station and better understand the overall performance of the Davis AirLink.

2.4 Data Analysis

We created the algorithm calibration graphs using twelve-day sensor measurement datasets from Pasak Jolasid Dam, Supattra Resort, and Walailak University, as well as twelve-day sensor datasets and data from the Air4Thai and Gistda websites. We used the one-way ANOVA test to examine PM2.5 levels and linear regression analysis to explore the relationship between PM2.5 concentrations at the three locations.

2.5 GLOBE Observer Application: Air temperature and Relative humidity

This study used the GLOBE Atmosphere Protocol to collect the air temperature and relative humidity using the Davis weather station at three sites (https://www.globe.gov/web/s-cool). Air temperature and relative humidity data collection began after the sensors were installed at three locations: the Pasak Jolasid Dam, Supattra Resort, and Walailak University, Nakhon Si Thammarat. The two locations, Pasak Jolasid Dam and Supattra Resort, conducted a three-day data collection campaign from November 25–27, 2024, and Walailak University, Nakhon Si Thammarat, conducted a 12-day data collection campaign from November 15–27, 2024. The instruments could record high-resolution measurements from Davis AirLink during the same period. These reference data were retrieved from the DavisNet cloud service, which stores readings every five minutes, resulting in a 24-hour dataset.

3. Results and Discussion

3.1 Compare PM 2.5 values of each location using Davis AirLink.

We compared PM2.5 particulate matter levels with Compare PM2.5 with Walailak University, Supattra Resort, and Pasak Jolasid Dam. We found no association between these three sites (linear regression: $F_{2,6983}$ =57.521, P>0.001, Figure 3.1). The analysis of PM2.5 dust values across three distinct areas reveals variations in dust concentrations. Notably, Walailak University recorded the lowest dust value at 13.1802. This may be attributed to its designation as an educational zone, characterized by abundant greenery and fewer activities contributing to pollution. In contrast, Suphattra Resort exhibited a slightly elevated dust value of 13.8066, likely due to its nature as a tourist destination, which results in increased travel and associated human activities. Pasak Jolasid Dam, on the other hand, presented the highest dust value at

15.6065. This may be explained by the area's topography, which allows for the accumulation of windblown dust from surrounding activities, such as agriculture and transportation. Consequently, the variations in dust levels across these regions can be attributed to the differing activities and environmental conditions in each area.

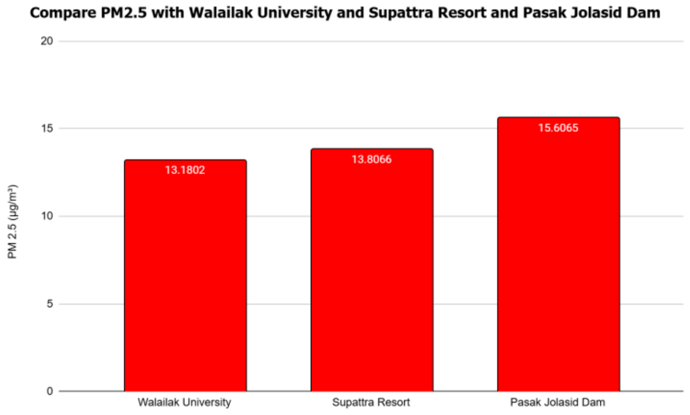
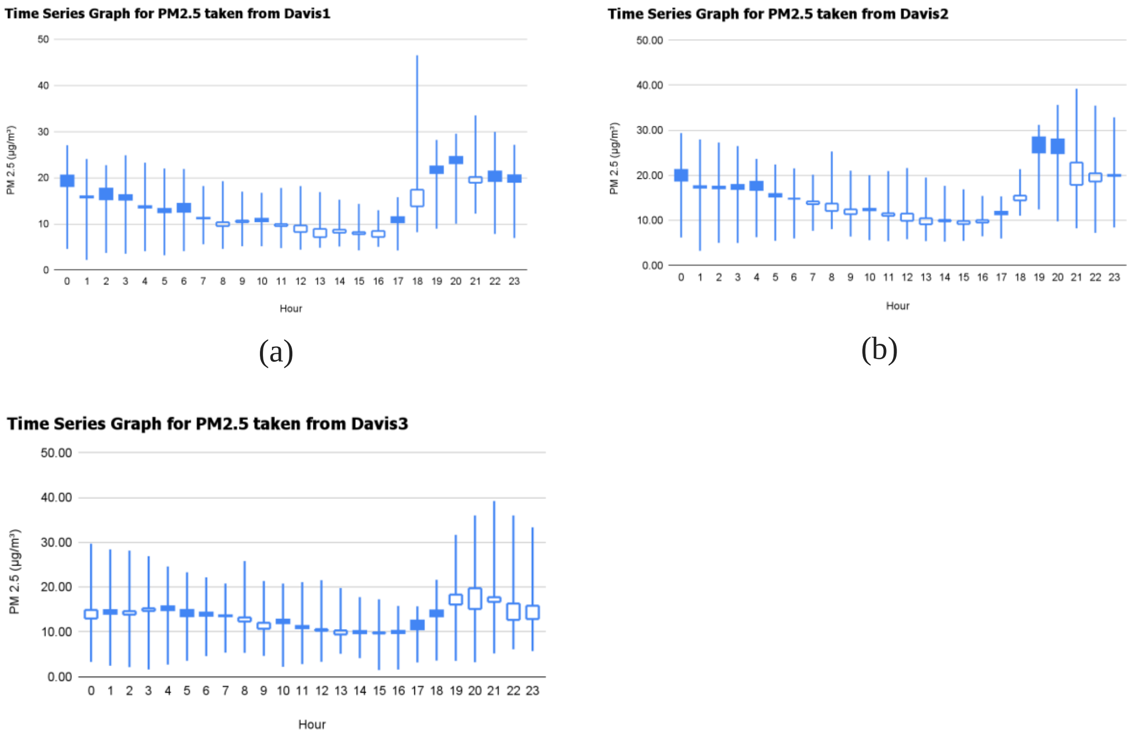


Figure 3.1 Compare PM2.5 with Walailak University, Supattra Resort, and Pasak Jolasid Dam

The three graphs in Figure 3.2 showed that PM2.5 continuously decreased from 00.00 to 17.00, increasing around 18.00 to 23.00 in every graph. In Figure 3.2a, PM2.5 at Walailak University was high at night because sappanwood burns and fires to repel mosquitoes for the buffalos. In Figure 3.2b, PM2.5 at Supattra Resort was high because there was a factory in that area. In Figure 3.2c, PM2.5 at Pasak Jolasid Dam was high because many cars or other vehicles were used at Pasak Jolasid Dam.



(a) (b) (c)

Figure 3.2 Compare hourly PM2.5 measurement with Davis station at (a) Walailak University, (b) Supattra Resort, and (c) Pasak Jolasid Dam.

According to the data presented in Figure 3.3, PM2.5 dust levels in Saraburi and Nakhon Si Thammarat consistently decreased from January to May. In January, Saraburi recorded nearly 50 µg/m³ dust, reduced to approximately 20 µg/m³ by May. In contrast, during the summer months from February to May, Chiang Mai and Phitsanulok experienced a significant rise in PM2.5 dust levels, increasing from around 37 µg/m³ to 75 µg/m³ in March. This trend culminated in an approximately 85 µg/m³ peak in April, followed by a gradual decline.

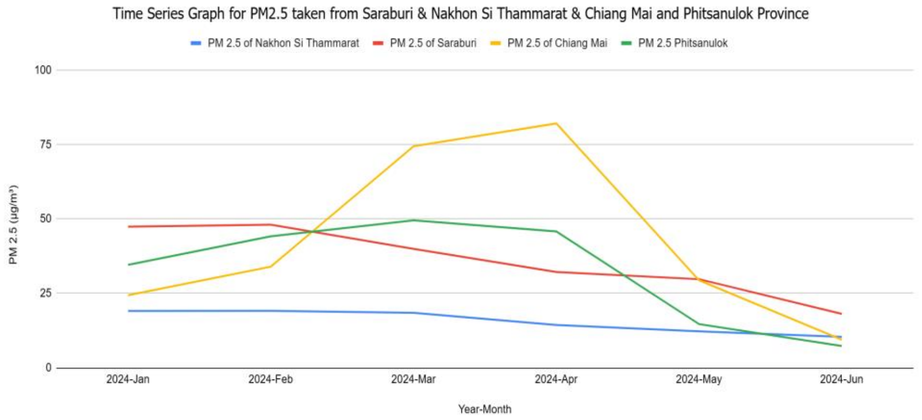


Figure 3.3 This graph shows that PM2.5 increased in January - June, and PM2.5 has decreased.

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, as 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 vertical and horizontal size of the clouds and the time it takes them to form, move, and dissipate.

4. Conclusion

This research is a preliminary study of air quality in different areas. The results will help to understand the current air quality situation and serve as basic information for future air quality management planning. The data is collected 24 hours a day for 12 days. The data from the graph can be roughly summarized as follows: Each location will have different PM2.5 values. This is because certain situations are different. For example, Supattra Resort and Walailak University will have higher PM2.5 values than other places because they burn sappanwood, which creates more PM2.5. Many cars pass by, creating dust from exhaust fumes. In February-May, PM2.5 increased; after May, PM2.5 decreased because February-May was 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 fine 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. Graph to see how the data relates.

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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