

Impact of Incremental Incense Stick Consumption on PM2.5 Loading: Implications for Indoor Air Quality



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INTRODUCTION

Natural Sources



Vocanic Eruptions

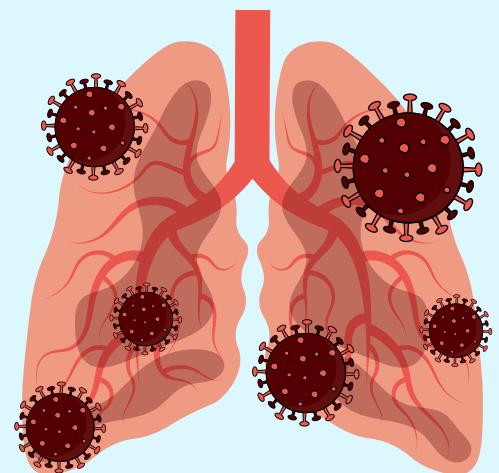


Forest Fires



Dust Storms

Respiratory Diseases



Chronic Bronchitis



Asthma



Lung Cancer

INTRODUCTION

Man-Made Sources



Burning Fossil Fuels



Construction Sites

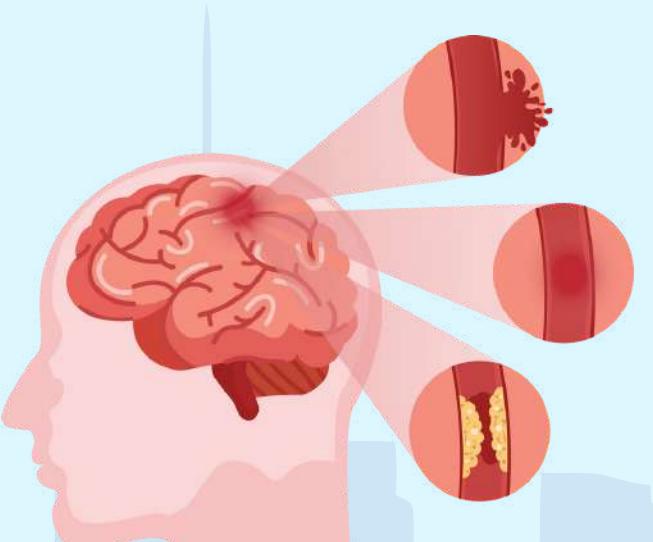


Burning Incense Sticks

Heart Diseases



Heart Attacks

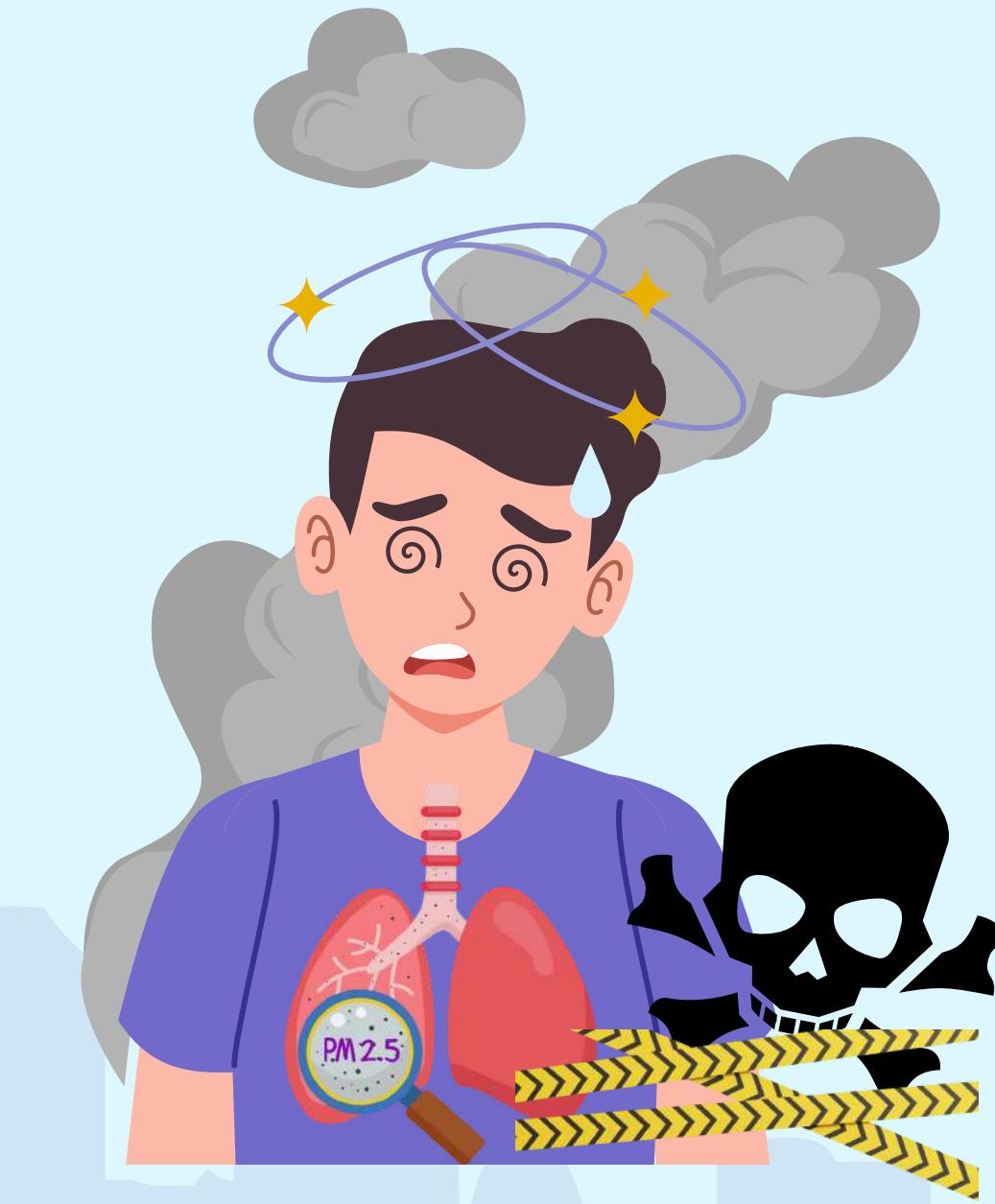


Stroke

HOW DOES PM2.5 AFFECT OUR HEALTH?



PM2.5 pollution affect
10 million people worldwide



Kill 30,000 people/year
in Thailand



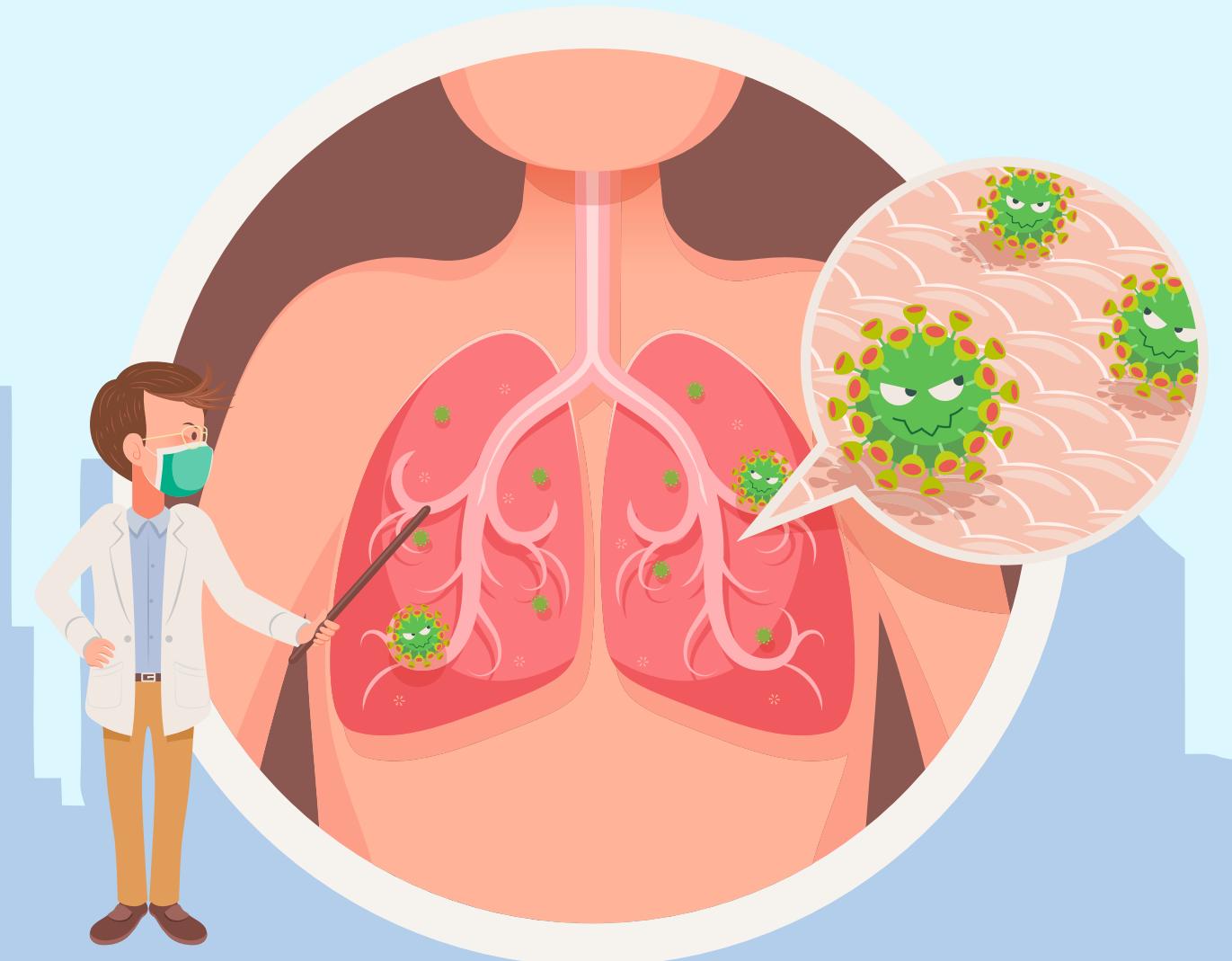
Thailand ranked 10th
PM2.5 in Asia

HOW DOES PM2.5 AFFECT OUR HEALTH?

Lung Cancer



Pneumonia



Throat Cancer



OBJECTIVES

- To quantify and compare the impact of incremental incense stick consumption (2, 5, and 9 sticks) on PM2.5 mass loading within a controlled indoor environment.
- To analyze the dynamic accumulation and persistence patterns of PM2.5 over a fixed temporal scale to identify the rate of indoor air quality degradation.
- To assess the implications for indoor air quality and public health by comparing recorded concentrations against international safety standards (AQI).

EXPERIMENTAL DESIGN

HOW DOES THE NUMBER OF INCENSE
STICK AFFECT THE AMOUNT
OF PM2.5 IN THE AIR?

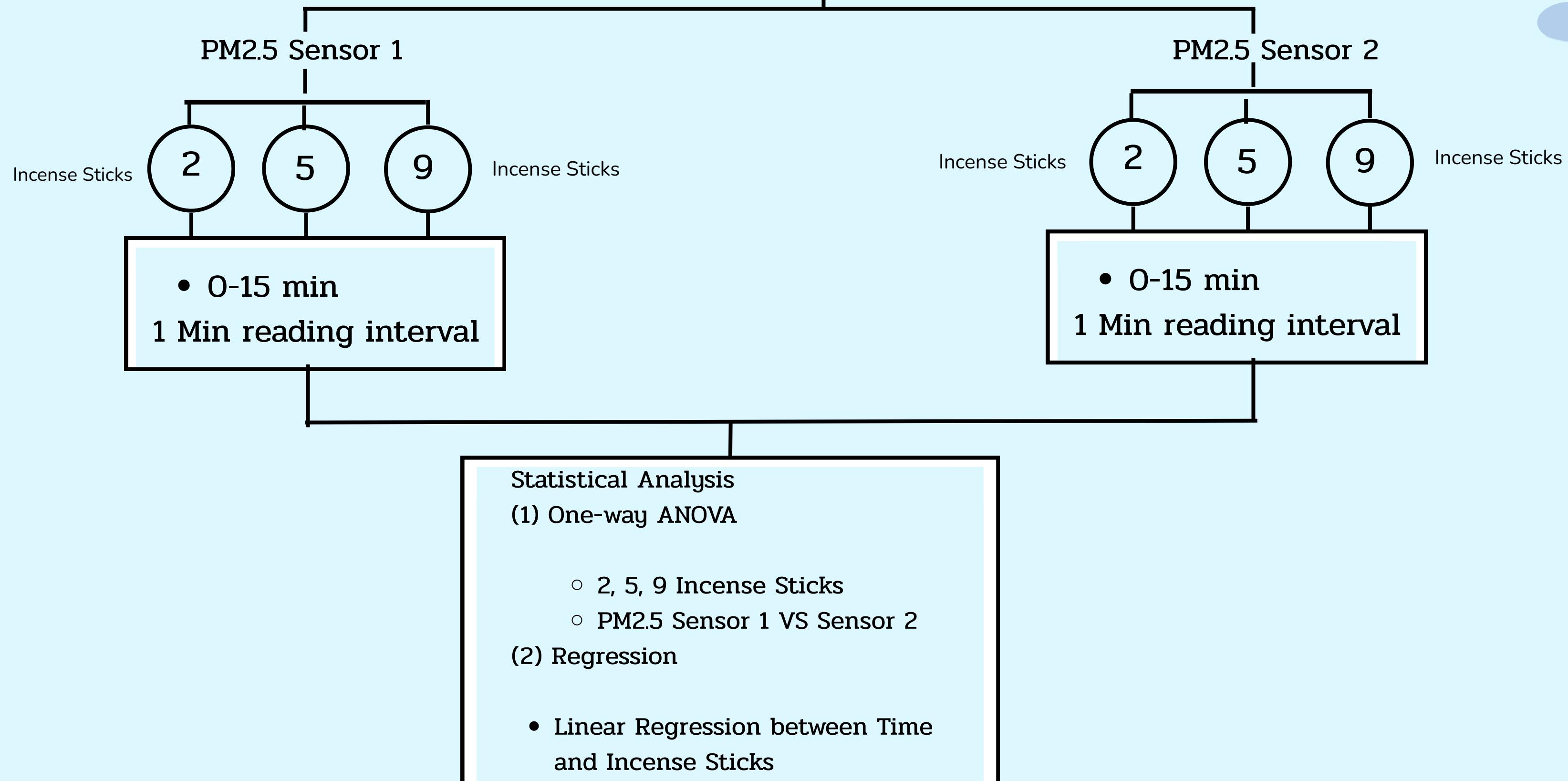
IoT PM2.5 01

IoT PM2.5 02

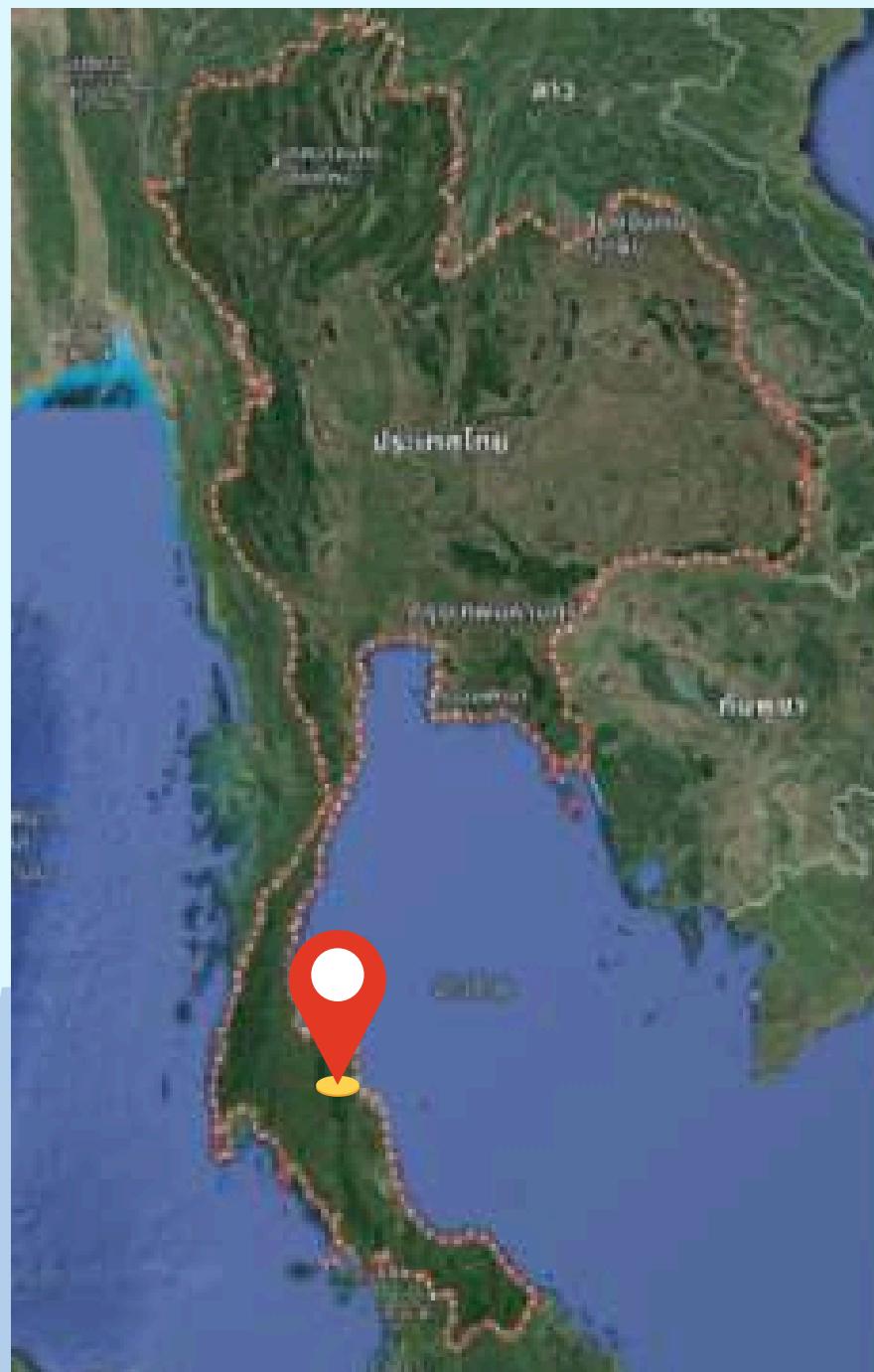
DATA ANALYSIS

EXPERIMENTAL DESIGN

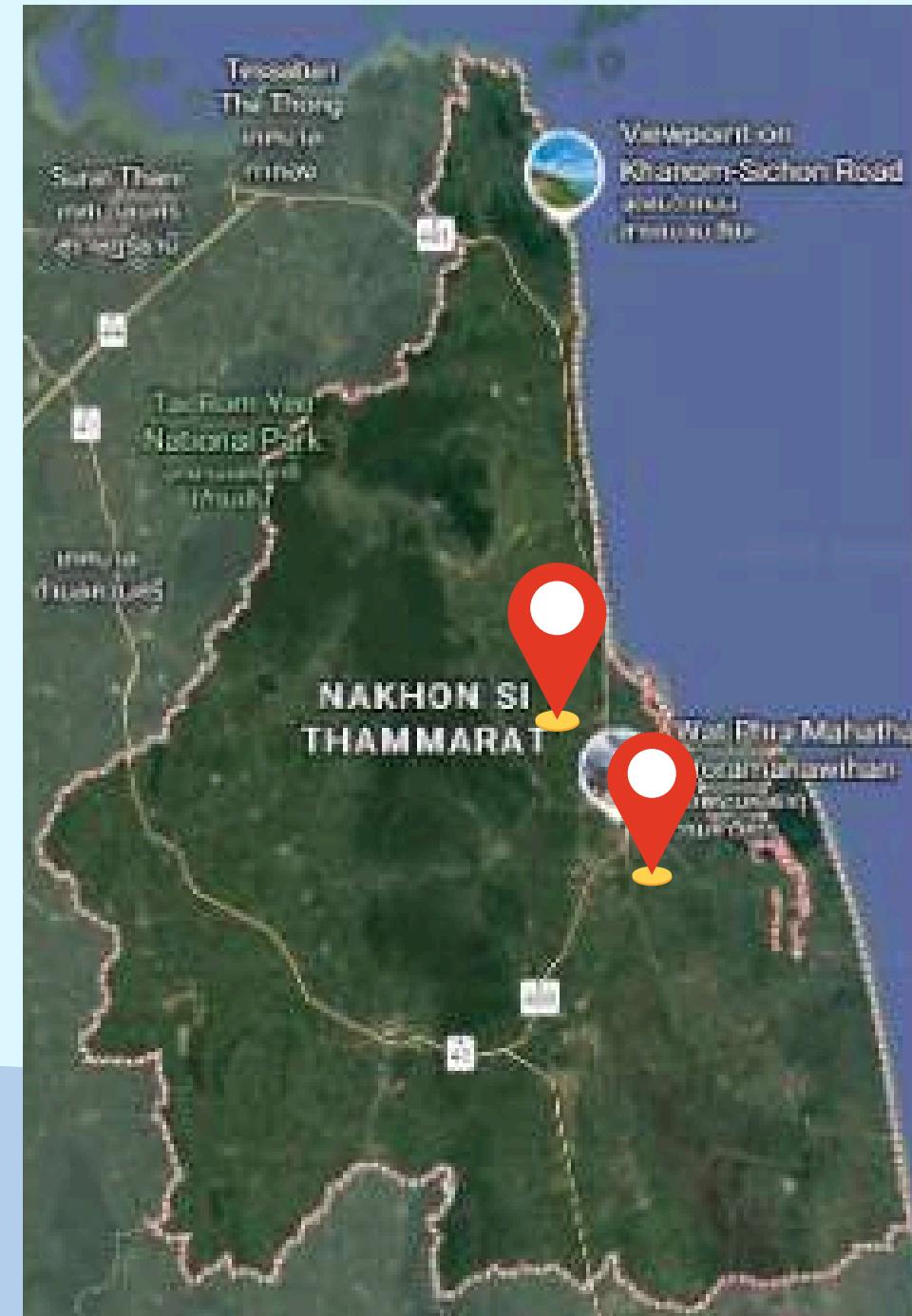
Impact of Incremental Incense Stick Consumption on PM2.5 Loading: Implications for Indoor Air Quality



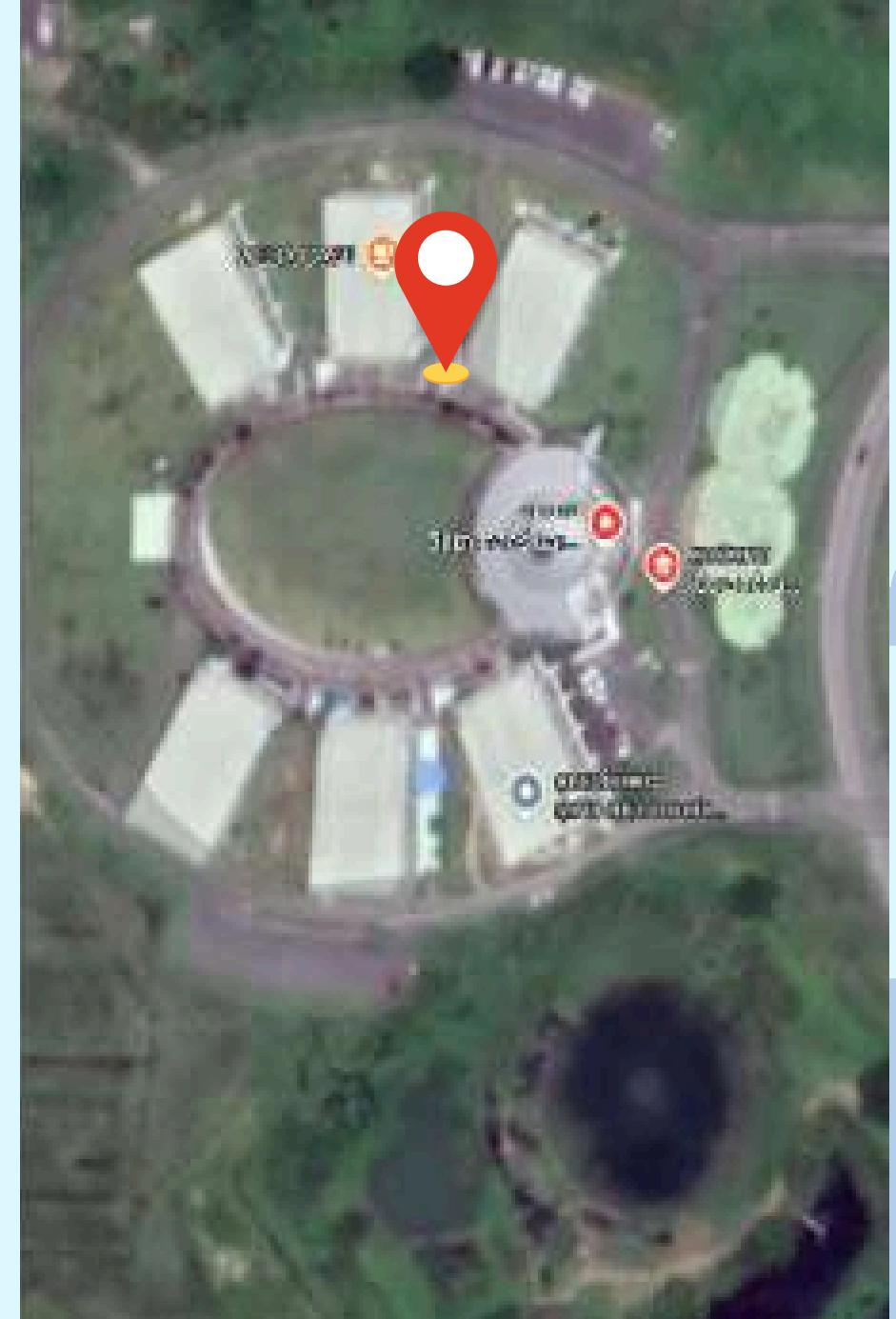
STUDY SITES



Thailand Map



Nakhon Si Thammarat



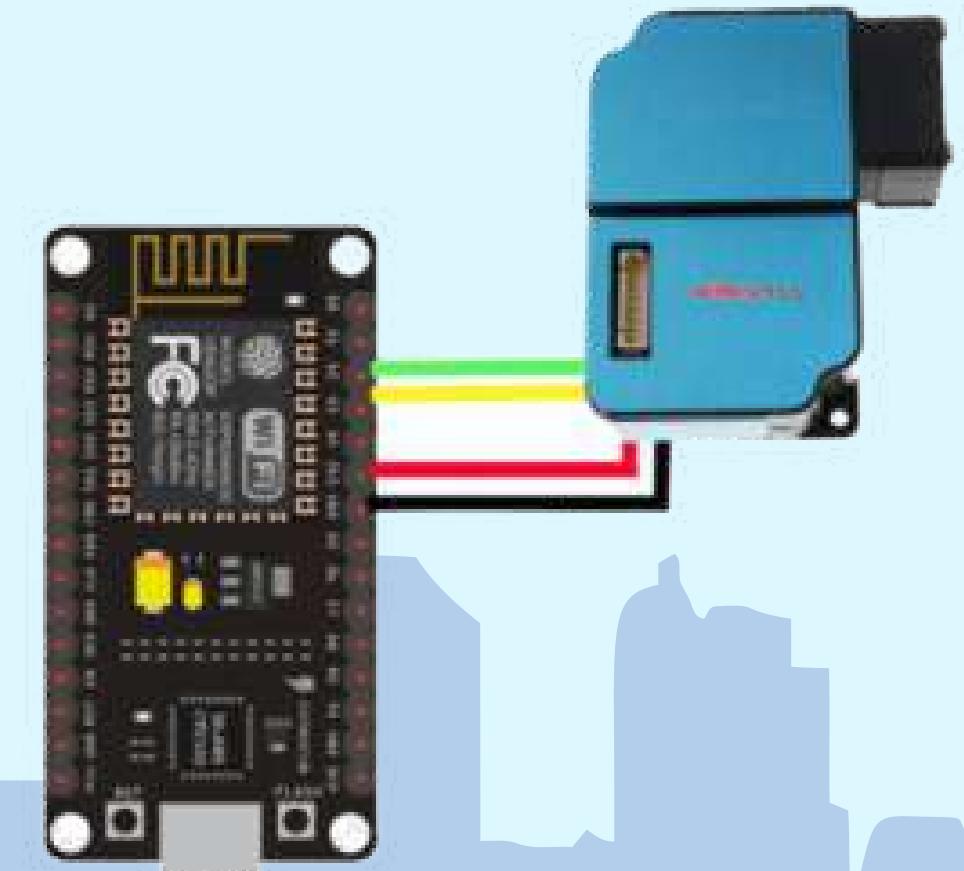
Walailak University



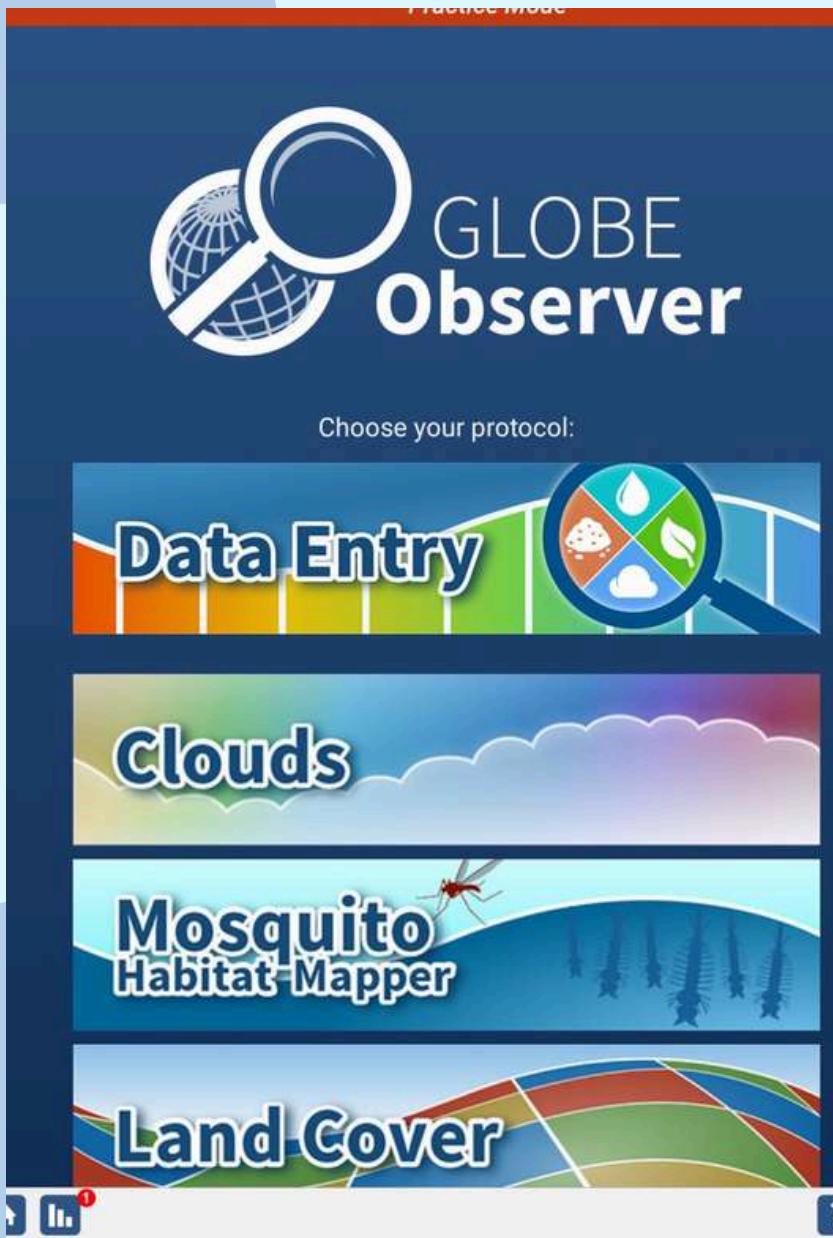
PM2.5 MEASUREMENTS



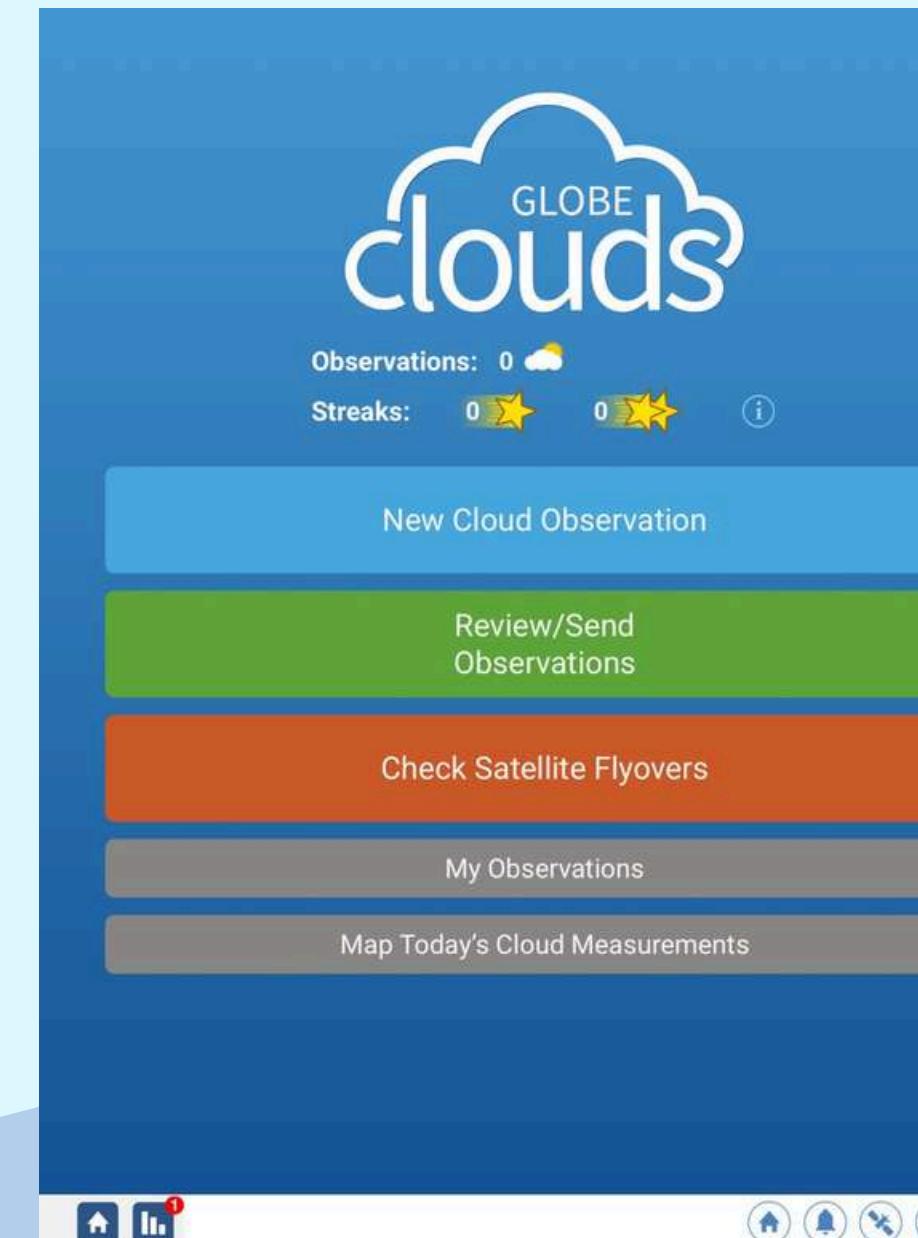
Sensor Pm2.5



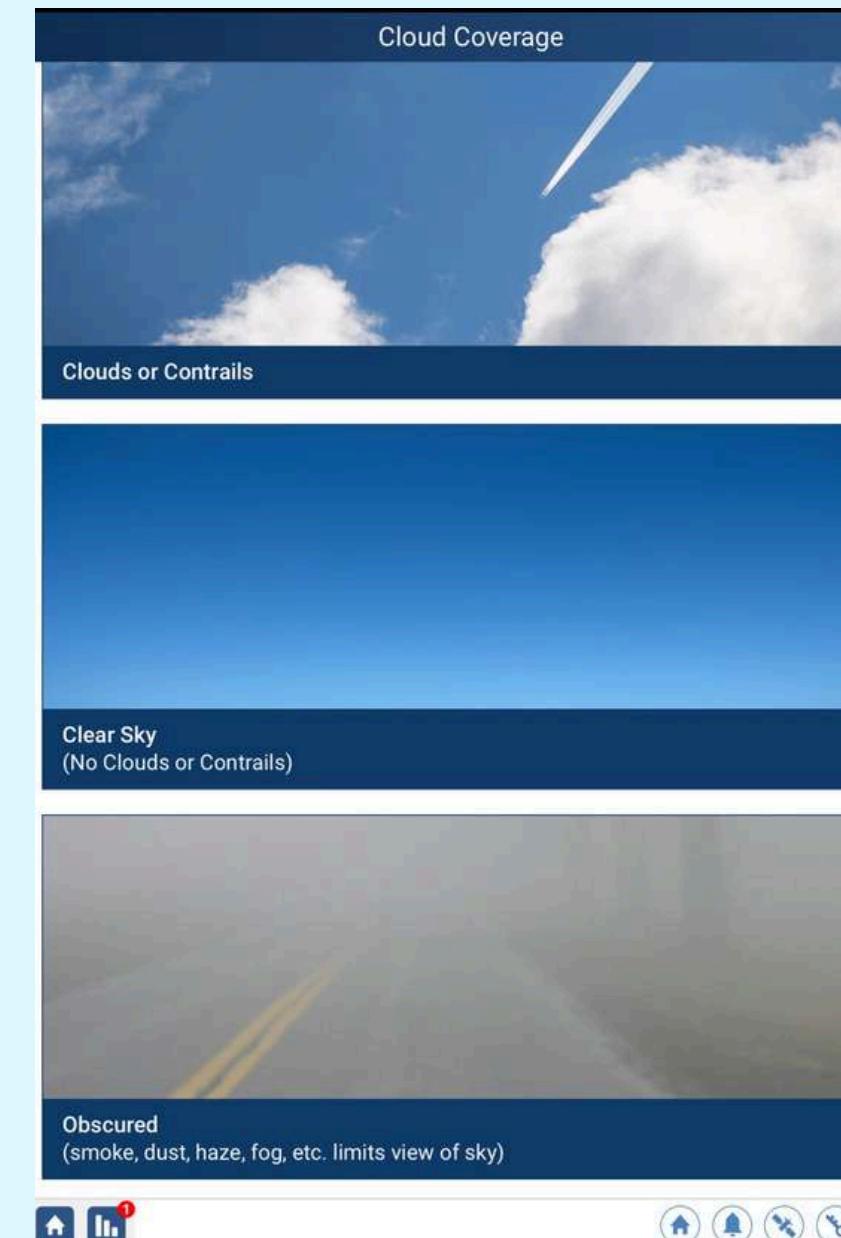
GLOBE CLOUD APP



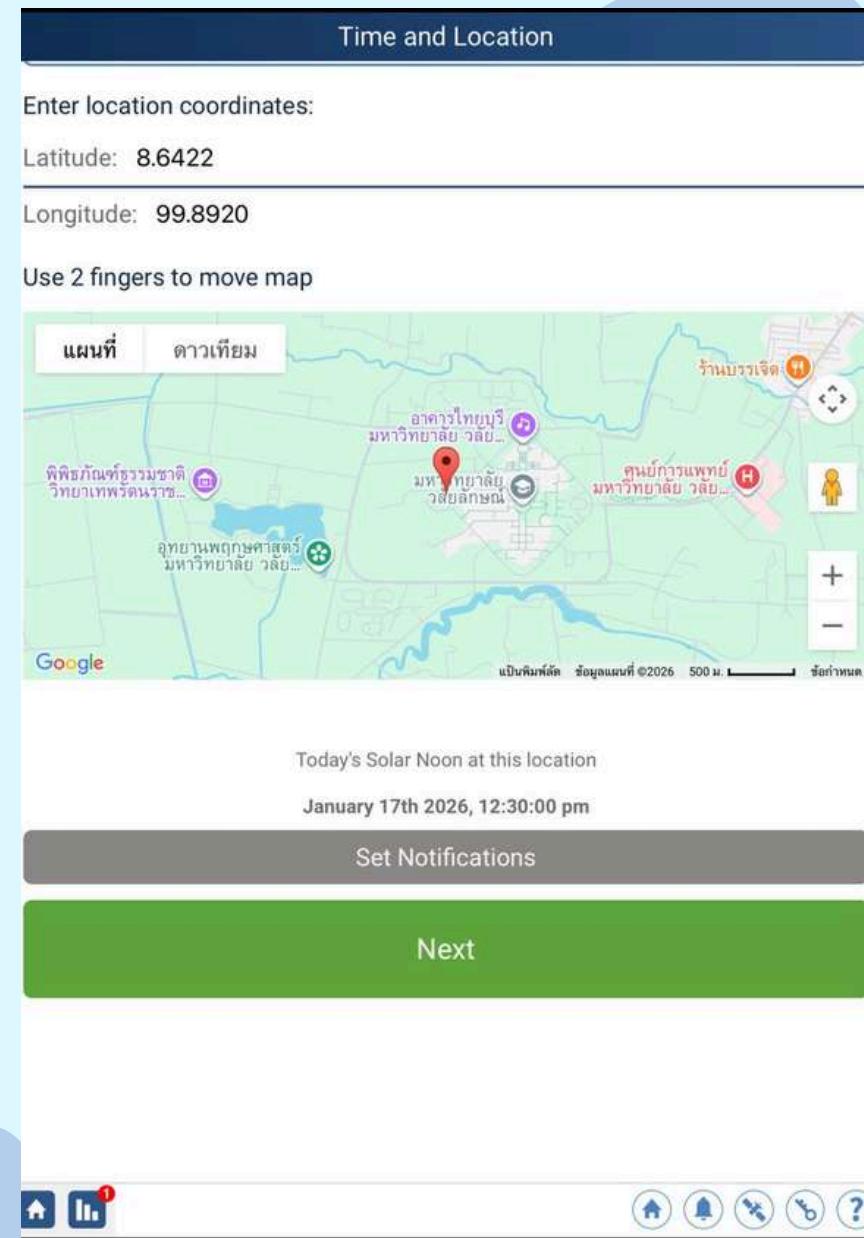
1. Choose Cloud App



2. Choose New Cloud Observation



3. Observe the sky, the cloud



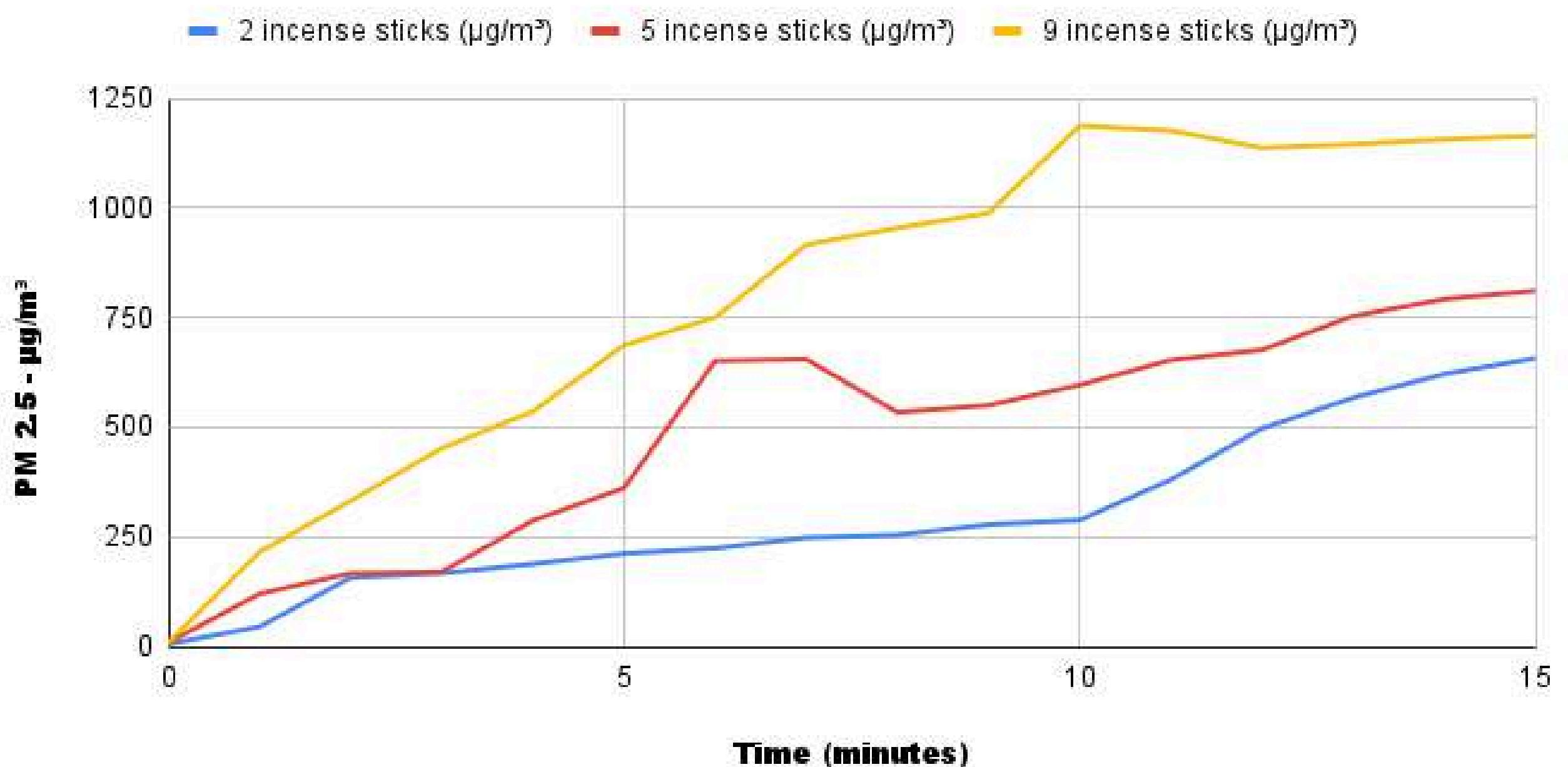
4. Latitude and Longitude of Study Sites

PM2.5 EXPERIMENT



RESULTS - EXPERIMENT 1

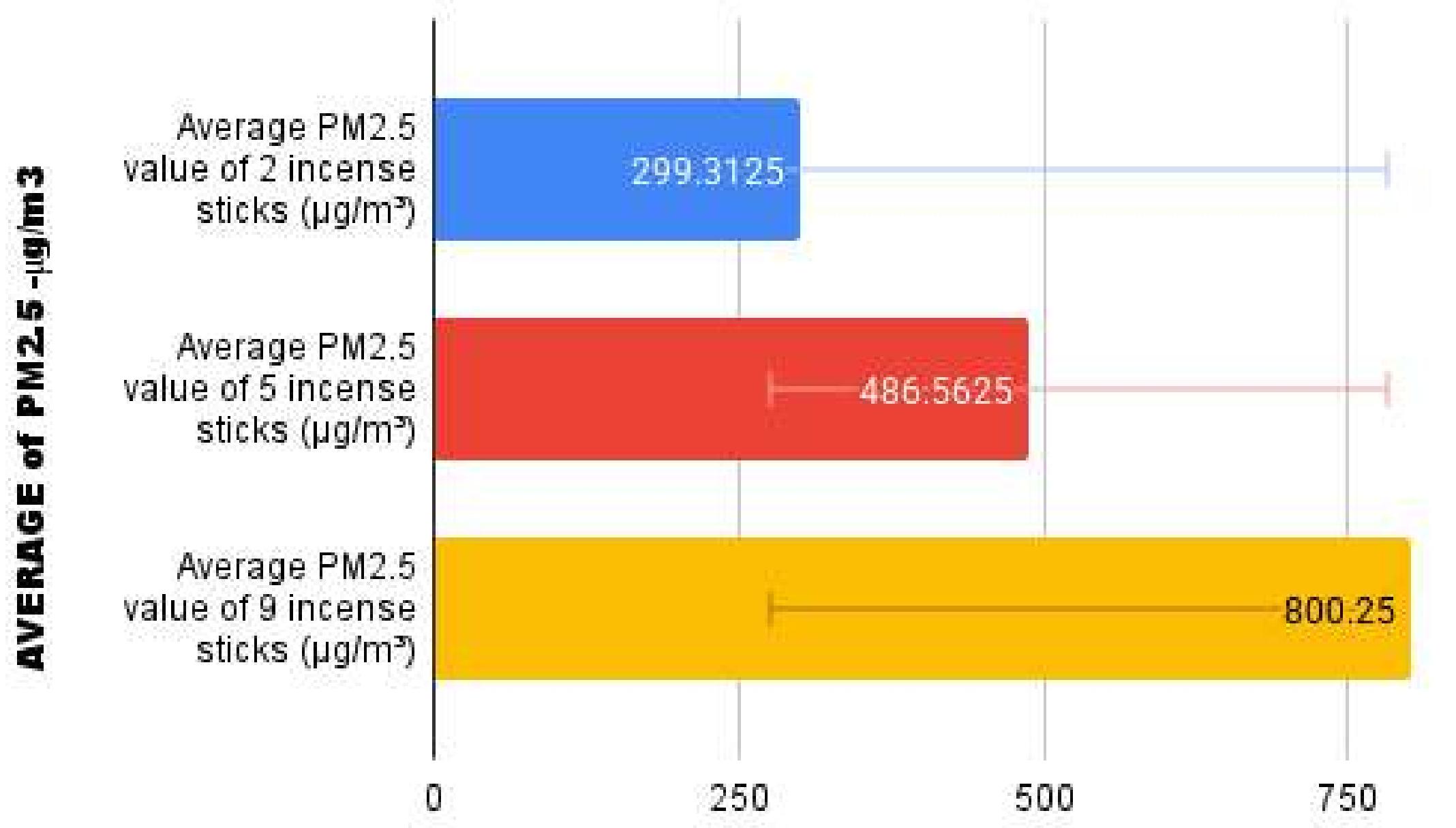
Experiment 1 Sensor 1. The increase in PM2.5 levels over a 15-minute period when burning different amounts



- **Rapid Increase:** PM2.5 rose sharply during the first few minutes in all groups.
- **Clear Dose Response:** 9 sticks produced the highest PM2.5, followed by 5 sticks, then 2 sticks.
- **Peak & Timing:** 9 sticks reached $\sim 1,164 \mu\text{g}/\text{m}^3$ at ~ 10 minutes (about $\sim 4\times$ higher than 2 sticks at the same time).
- **Persistence:** PM2.5 remained elevated throughout the 15-minute measurement period, especially for 9 sticks.

RESULTS - EXPERIMENT 1

Experiment 1 Sensor 1. Average PM2.5 levels for 2, 5 and 9 incense sticks.

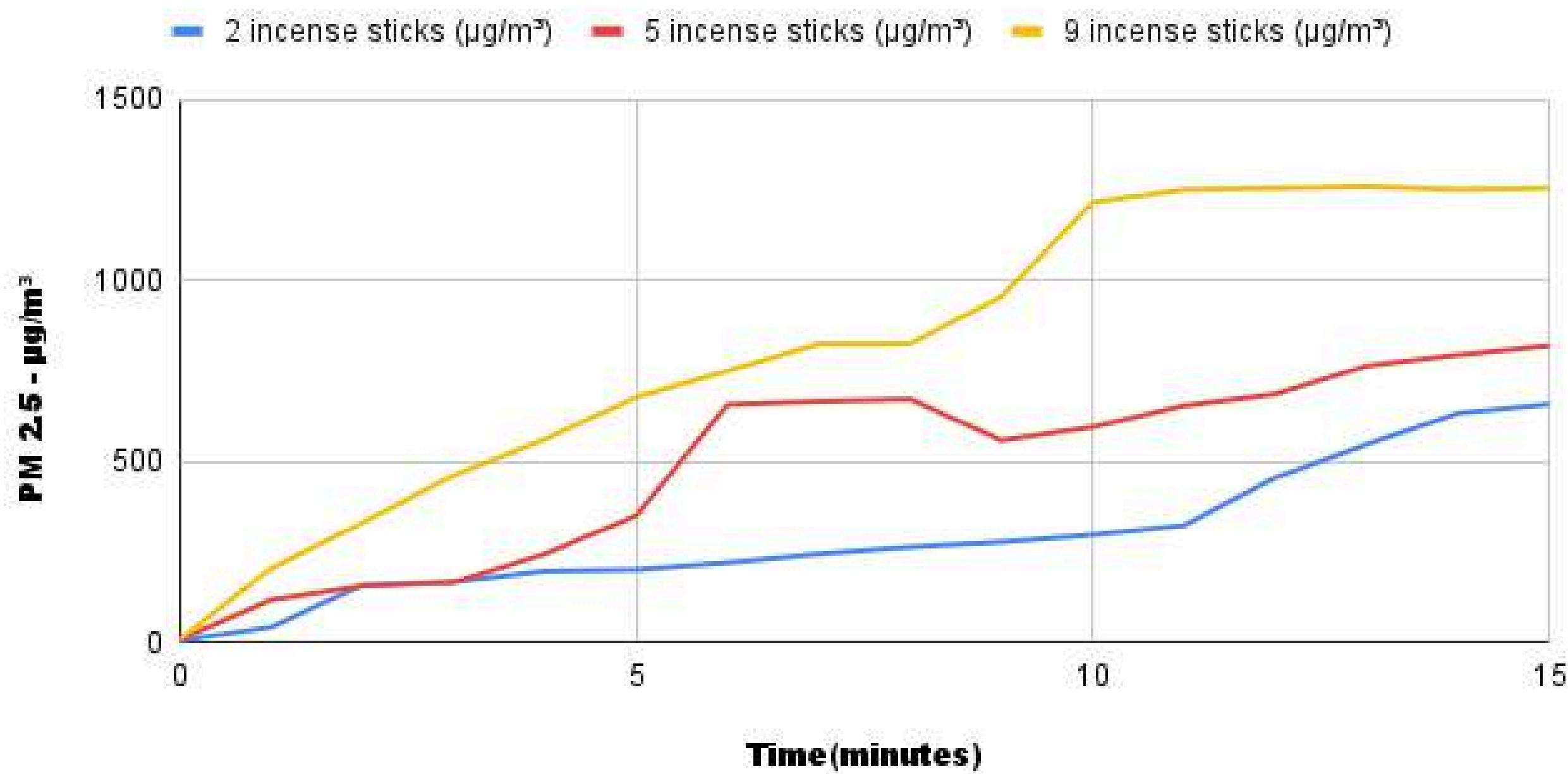


Average PM2.5 Concentration (Sensor 1, Experiment 1)

- Clear Increase: Average PM2.5 increased with incense quantity ($2 < 5 < 9$).
- Magnitude: 9 sticks averaged $800.25 \mu\text{g}/\text{m}^3$, about $2.7 \times$ higher than 2 sticks ($299.31 \mu\text{g}/\text{m}^3$).
- Interpretation: This supports a dose-response relationship between the number of incense sticks and indoor PM2.5.

RESULTS - EXPERIMENT 1

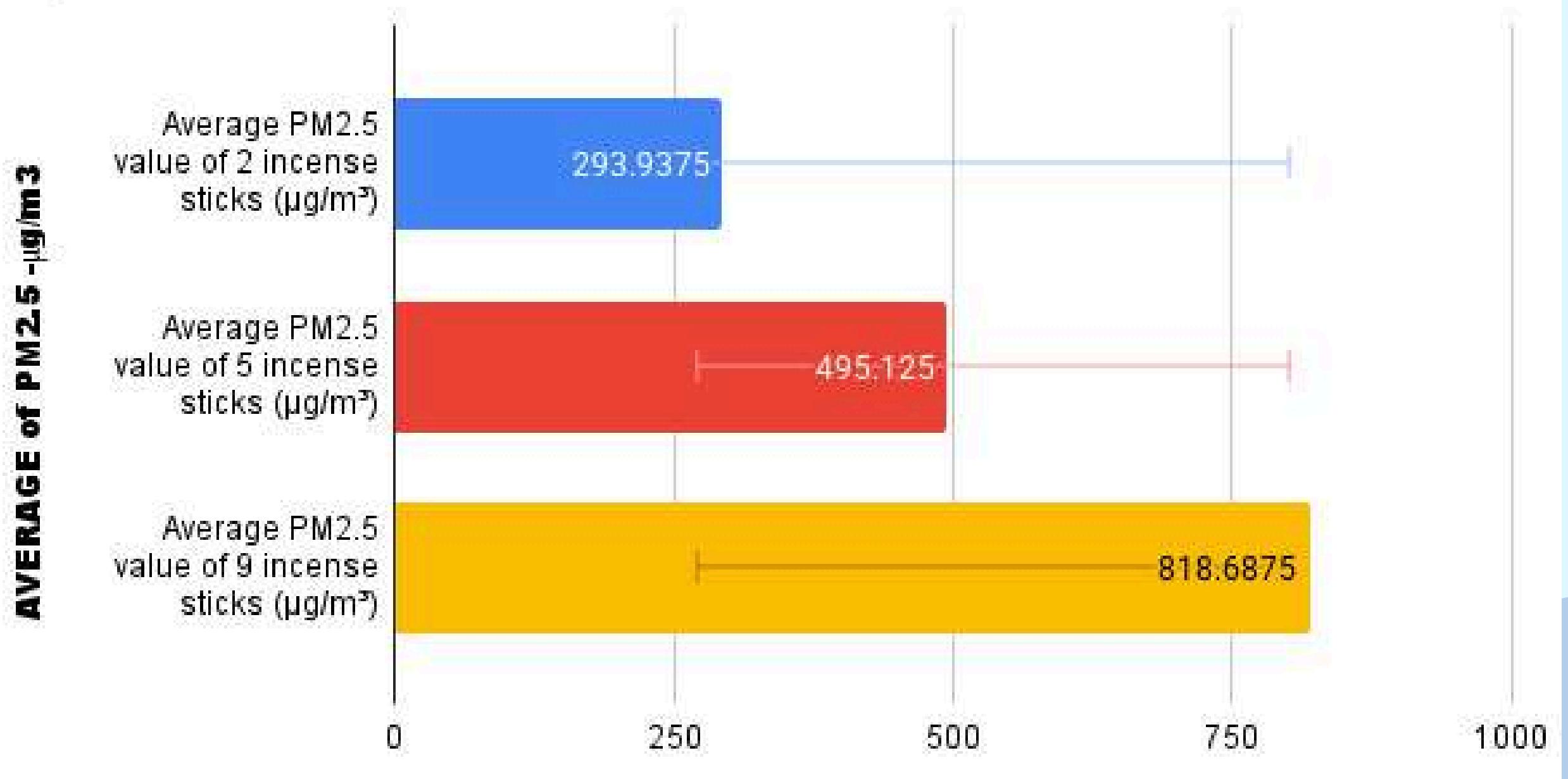
Experiment 1 Sensor 2. The increase in PM2.5 levels over a 15 minute period when burning different amounts



- Rapid Increase: PM2.5 rose quickly during the first few minutes in all groups.
- Clear Dose–Response: 9 sticks produced the highest PM2.5, followed by 5 sticks, then 2 sticks.
- Peak & Timing: 9 sticks reached $\sim 1,256 \mu\text{g}/\text{m}^3$ at ~ 10 minutes and remained high through 15 minutes.
- Persistence: PM2.5 stayed elevated throughout the 15-minute measurement period, especially for 9 sticks.

RESULTS - EXPERIMENT 1

Experiment 1 Sensor 2. Average PM2.5 levels for 2, 5 and 9 incense sticks.

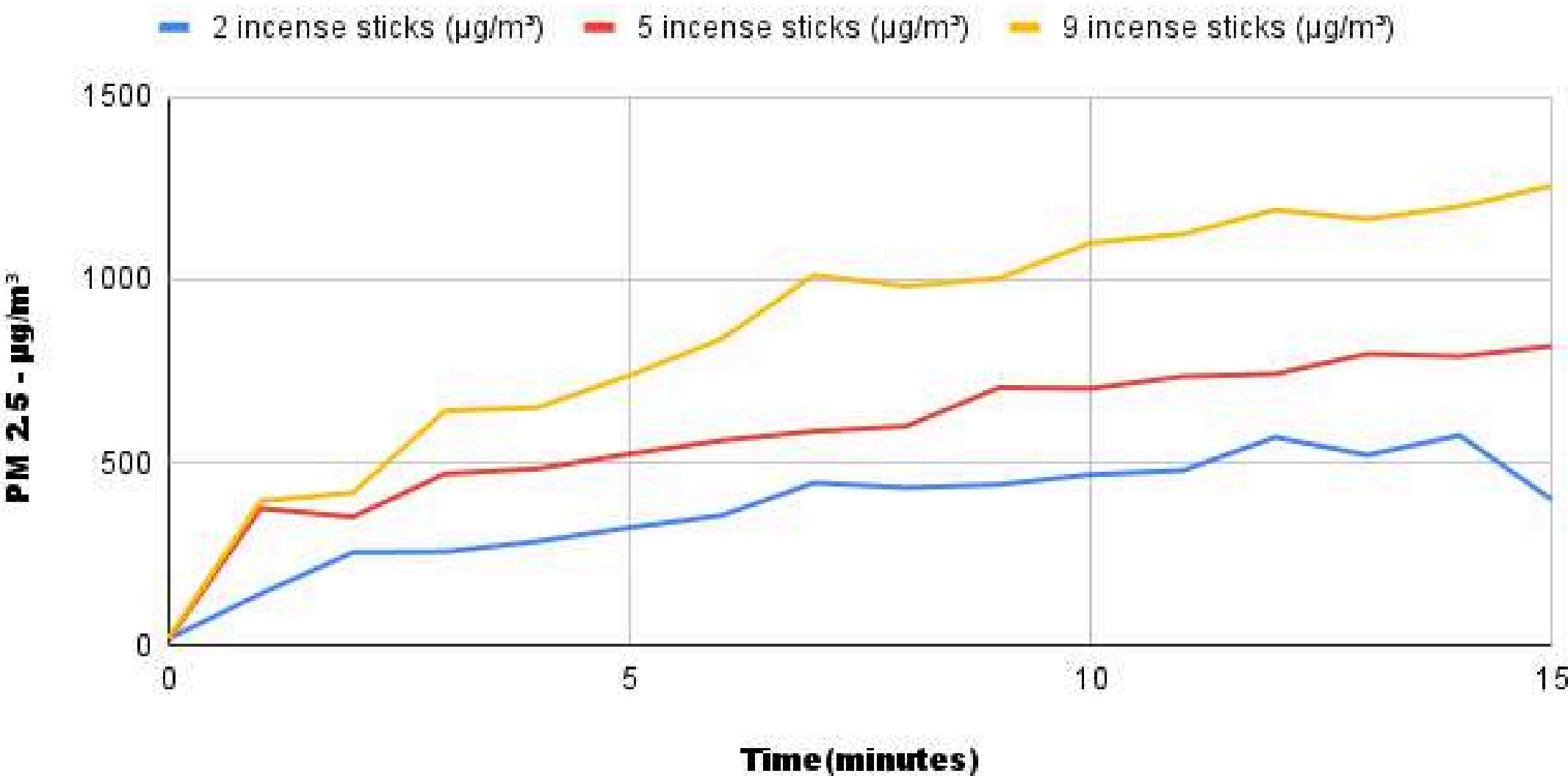


Average PM2.5 Concentration (Sensor 2, Experiment 1)

- Clear Increase: Average PM2.5 increased with incense quantity ($2 < 5 < 9$).
- Magnitude: 9 sticks averaged $818.69 \mu\text{g}/\text{m}^3$, about 2.8× higher than 2 sticks ($293.94 \mu\text{g}/\text{m}^3$).
- Interpretation: This supports a dose–response relationship between the number of incense sticks and indoor PM2.5 concentration.

RESULTS - EXPERIMENT 2

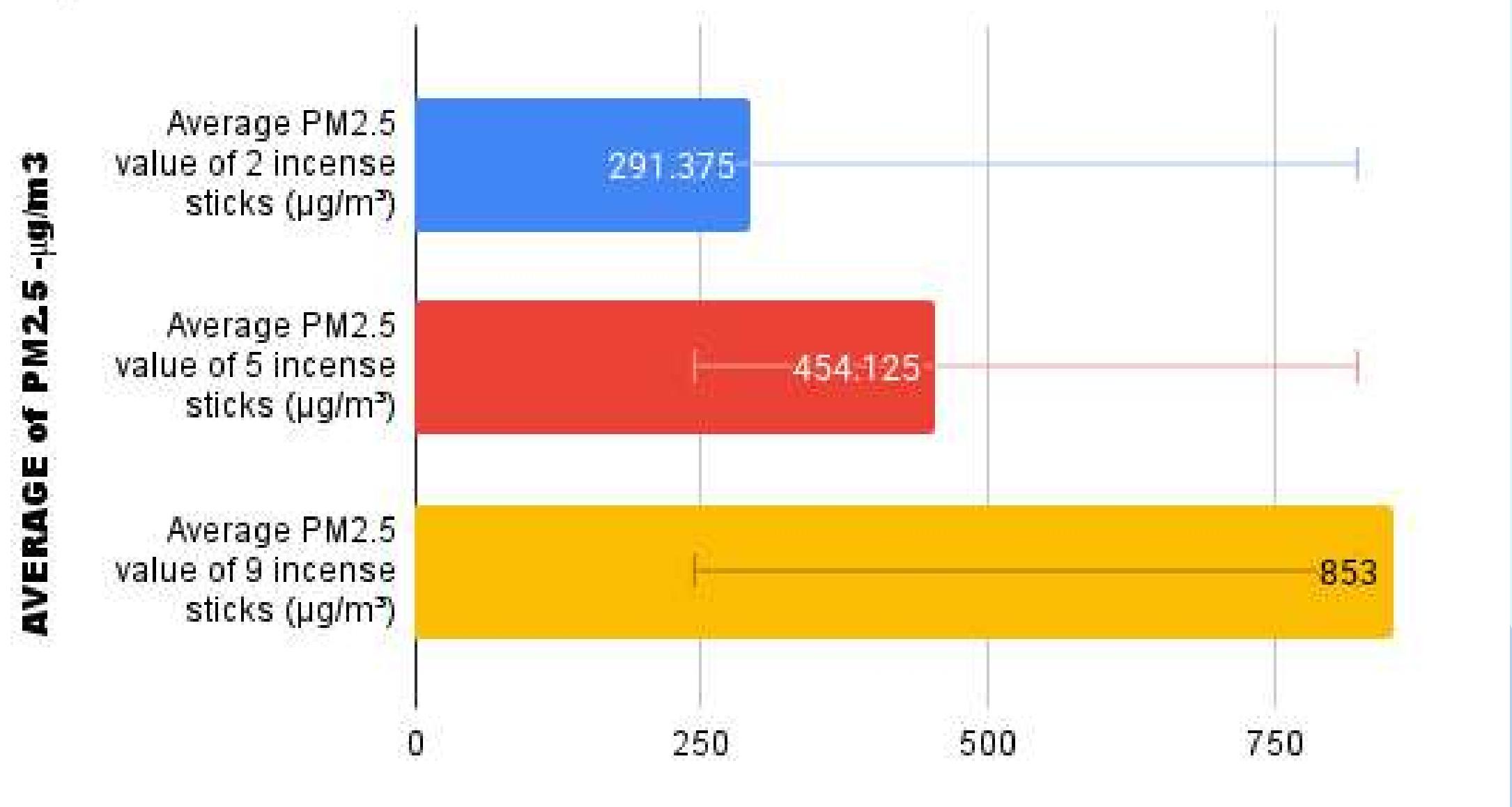
Experiment 2 Sensor 1. The increase in PM2.5 levels over a 15 minute period when burning different amounts



- Rapid Increase: PM2.5 rose quickly within the first few minutes in all groups.
- Clear Dose–Response: 9 sticks produced the highest PM2.5, followed by 5 sticks, then 2 sticks.
- Peak Level: 9 sticks reached $\sim 1,464 \mu\text{g}/\text{m}^3$ by the end of the 15-minute period.
- Persistence: PM2.5 stayed elevated throughout the 15-minute measurement, especially for 9 sticks.

RESULTS – EXPERIMENT 2

Experiment 2 Sensor 1. Average PM2.5 levels for 2, 5 and 9 incense sticks

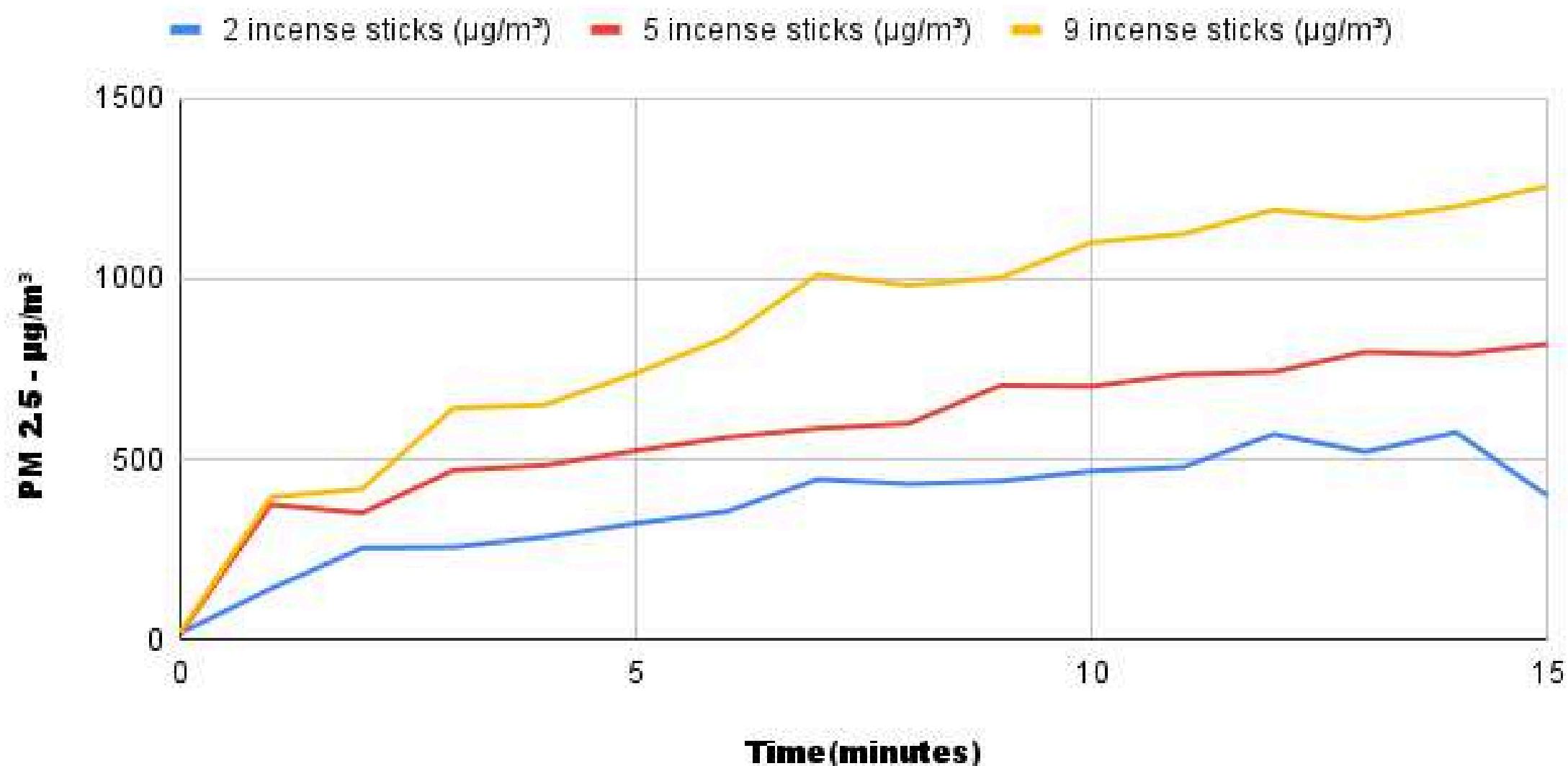


Average PM2.5 Concentration (Sensor 1, Experiment 2)

- Clear Increase: Average PM2.5 increased with incense quantity ($2 < 5 < 9$).
- Magnitude: 9 sticks averaged $853 \mu\text{g}/\text{m}^3$, about 2.9x higher than 2 sticks ($291.38 \mu\text{g}/\text{m}^3$).
- Interpretation: The results support a dose–response relationship between the number of incense sticks and indoor PM2.5 concentration.

RESULTS - EXPERIMENT 2

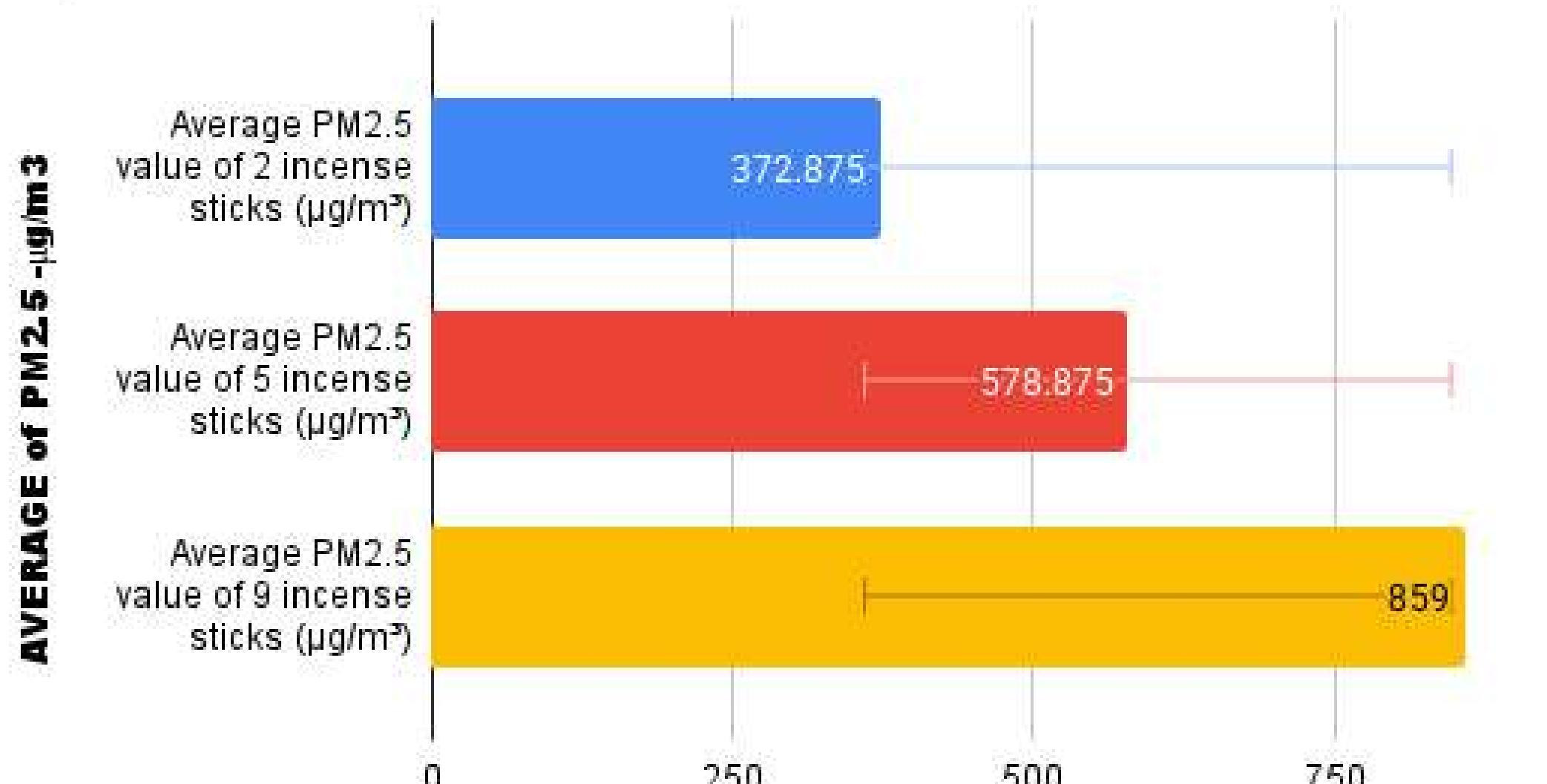
Experiment 2 Sensor 2. The increase in PM2.5 levels over a 15 minute period when burning different amounts



- Rapid Increase: PM2.5 rose quickly within the first few minutes in all groups.
- Clear Dose-Response: 9 sticks produced the highest PM2.5, followed by 5 sticks, then 2 sticks.
- Peak Level: 9 sticks reached $\sim 1,257 \mu\text{g}/\text{m}^3$ near the end of the 15-minute period.
- Persistence: PM2.5 remained elevated throughout the 15-minute measurement, especially for 9 sticks.

RESULTS - EXPERIMENT 2

Experiment 2 Sensor 2. Average PM2.5 levels for 2, 5 and 9 incense sticks

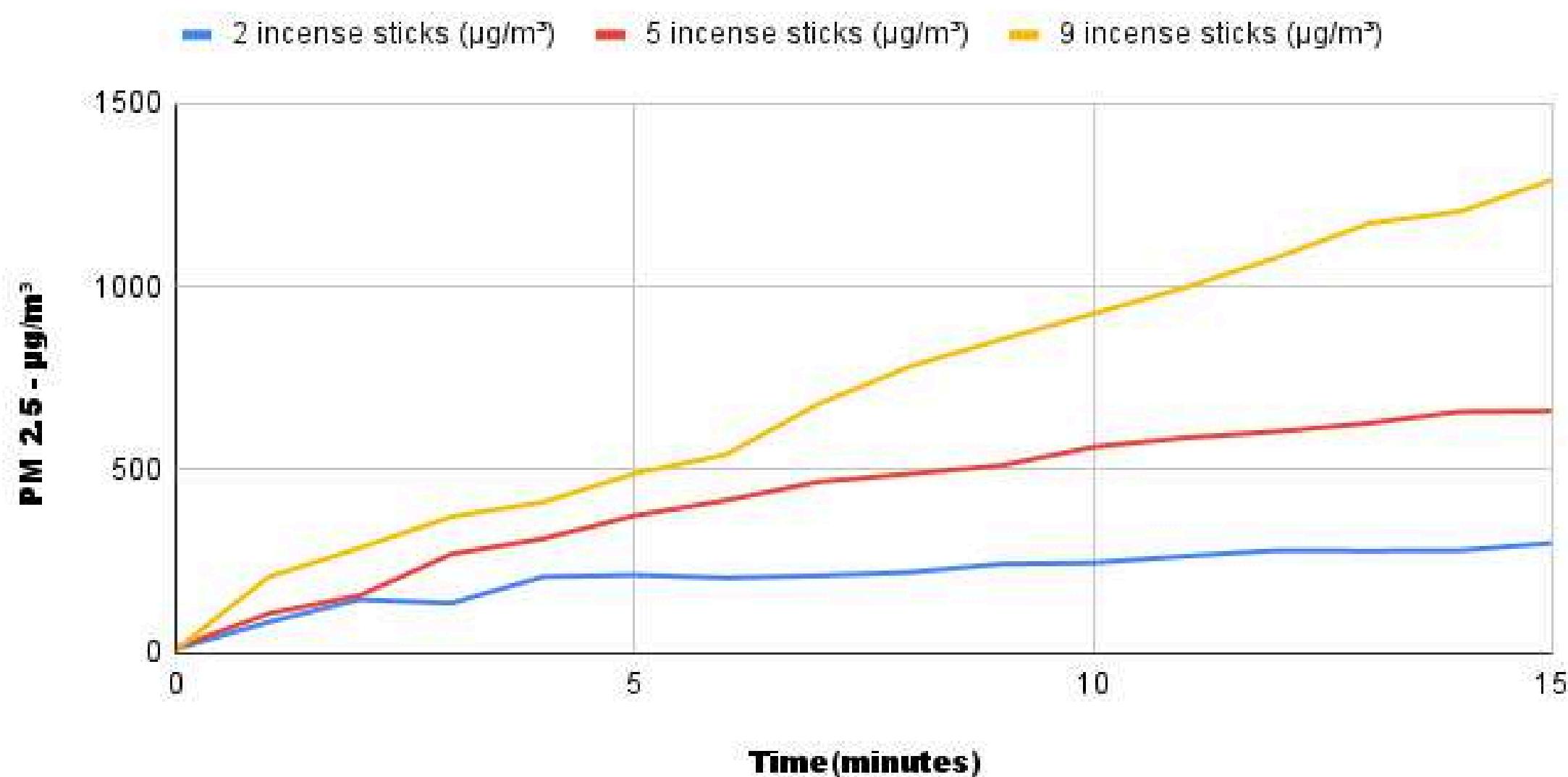


Average PM2.5 Concentration (Sensor 2)

- Mean PM2.5 increased with incense quantity: 2 sticks ($372.88 \mu\text{g}/\text{m}^3$) < 5 sticks ($578.88 \mu\text{g}/\text{m}^3$) < 9 sticks ($859.00 \mu\text{g}/\text{m}^3$).
- Magnitude of increase: 9 sticks produced $\sim 2.3 \times$ higher average PM2.5 than 2 sticks.
- Dose-response pattern: Results support a direct relationship between the number of incense sticks and indoor PM2.5 loading (with variability shown by error bars).

RESULTS - EXPERIMENT 3

Experiment 3 Sensor 1. The increase in PM2.5 levels over a 15 minute period when burning different amounts

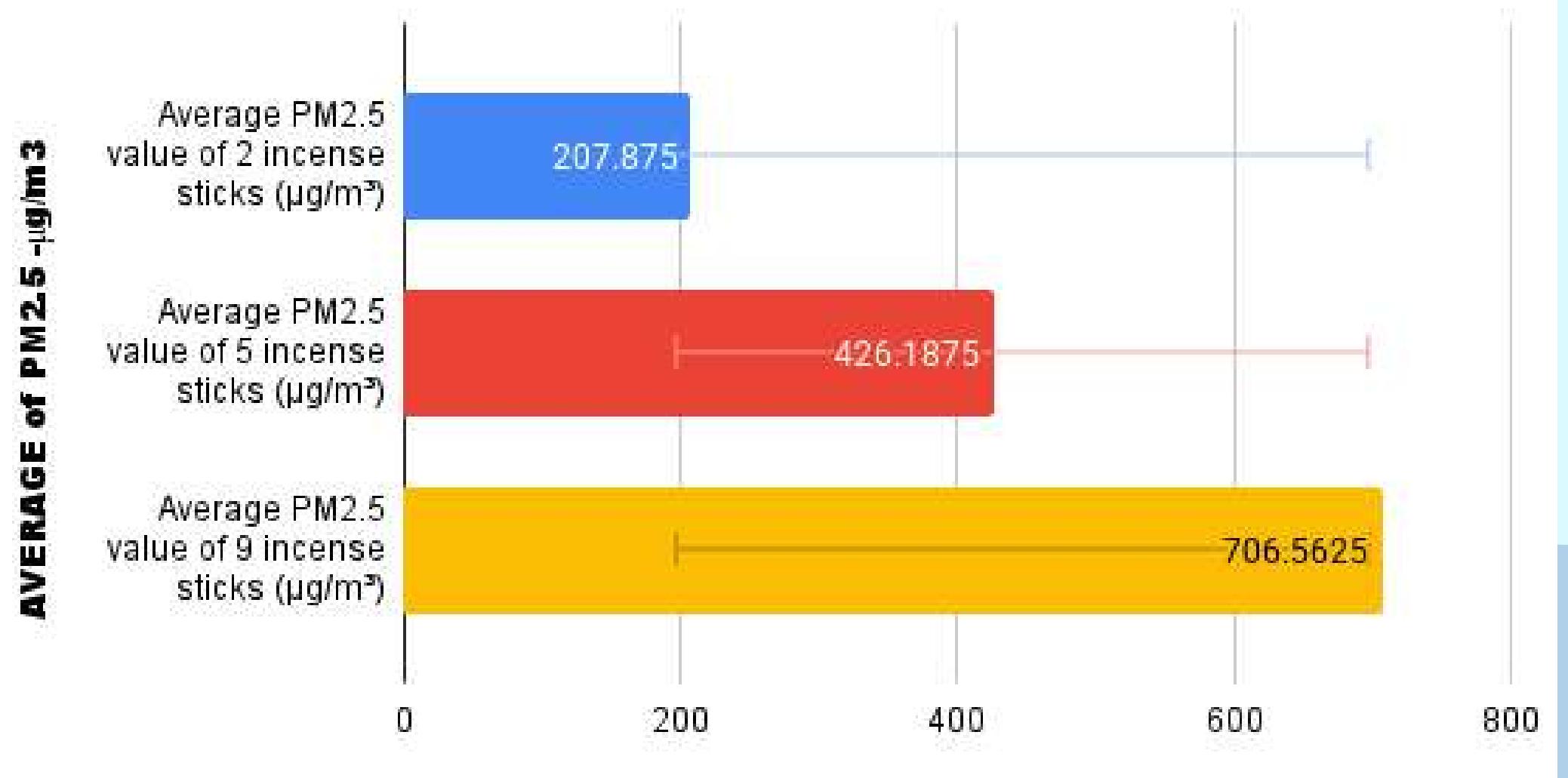


Key Findings (Experiment 3 – Sensor 1)

- Clear dose-response pattern: PM2.5 increased as incense quantity increased ($2 < 5 < 9$ sticks) throughout the 15-minute period.
- Peak loading: 9 sticks reached $\sim 1,290 \mu\text{g}/\text{m}^3$, compared with $\sim 300 \mu\text{g}/\text{m}^3$ for 2 sticks ($\approx 4\times$ higher).
- Faster accumulation at higher dose: The 9-stick condition climbed steeply and exceeded $\sim 1,000 \mu\text{g}/\text{m}^3$ by around minute 11–12.
- Continued buildup: PM2.5 kept rising over time with no clear plateau in this setup, indicating ongoing accumulation in the room.

RESULTS - EXPERIMENT 3

Experiment 3 Sensor 1. Average PM2.5 levels for 2, 5 and 9 incense sticks

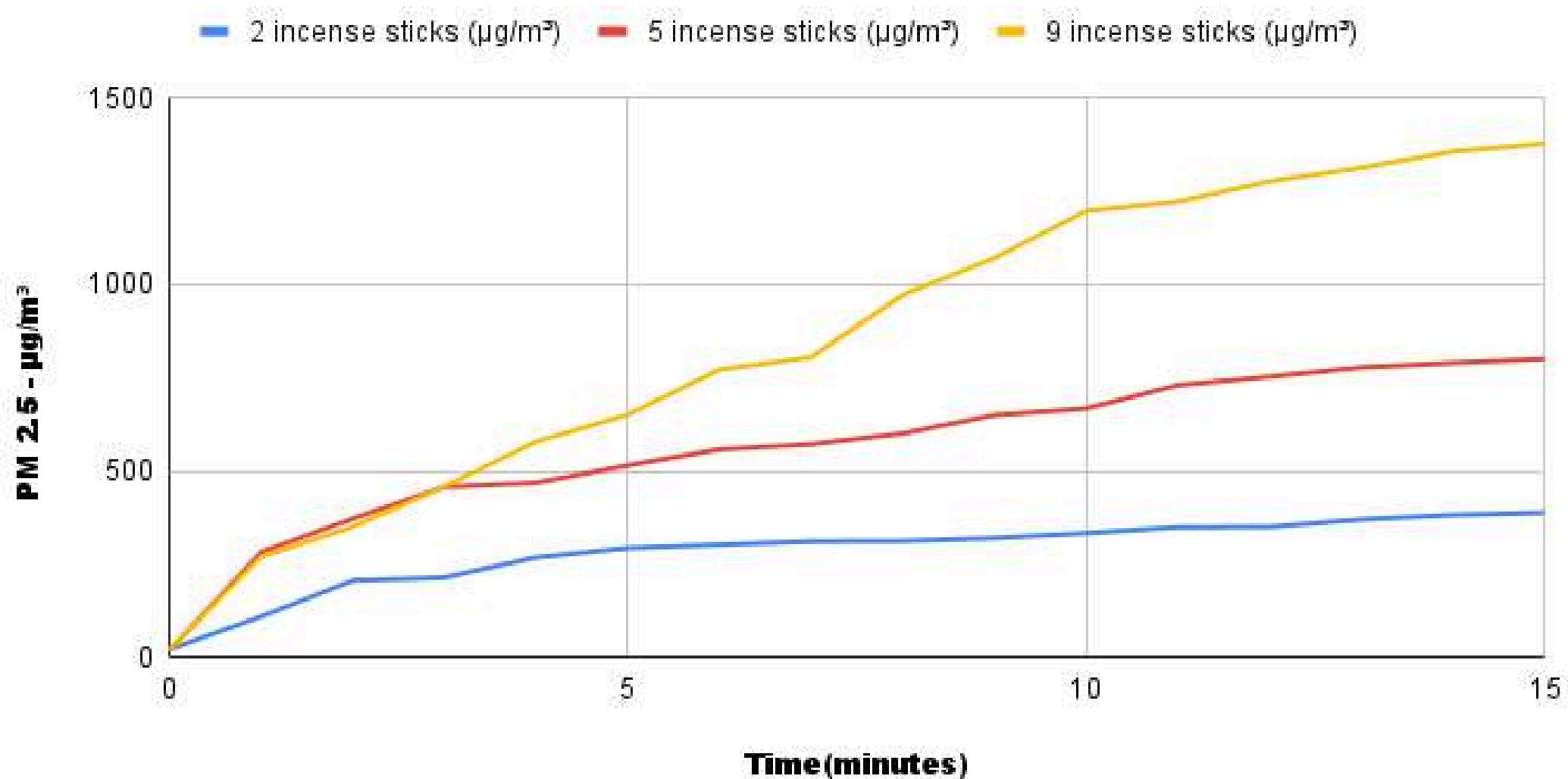


Average PM2.5 (Experiment 3 – Sensor 1)

- Dose response pattern: Mean PM2.5 increased as incense quantity increased (2 < 5 < 9 sticks).
- 15-min mean PM2.5 ($\mu\text{g}/\text{m}^3$): 2 sticks = 207.88, 5 sticks = 426.19, 9 sticks = 706.56.
- Relative increase: 9 sticks produced $\sim 3.4 \times$ higher PM2.5 than 2 sticks (and $\sim 1.7 \times$ higher than 5 sticks).
- Variability: Error bars indicate noticeable variation across trials, but the increasing trend remains consistent.

RESULTS - EXPERIMENT 3

Experiment 3 Sensor2. The increase in PM2.5 levels over a 15 minute period when burning different amounts

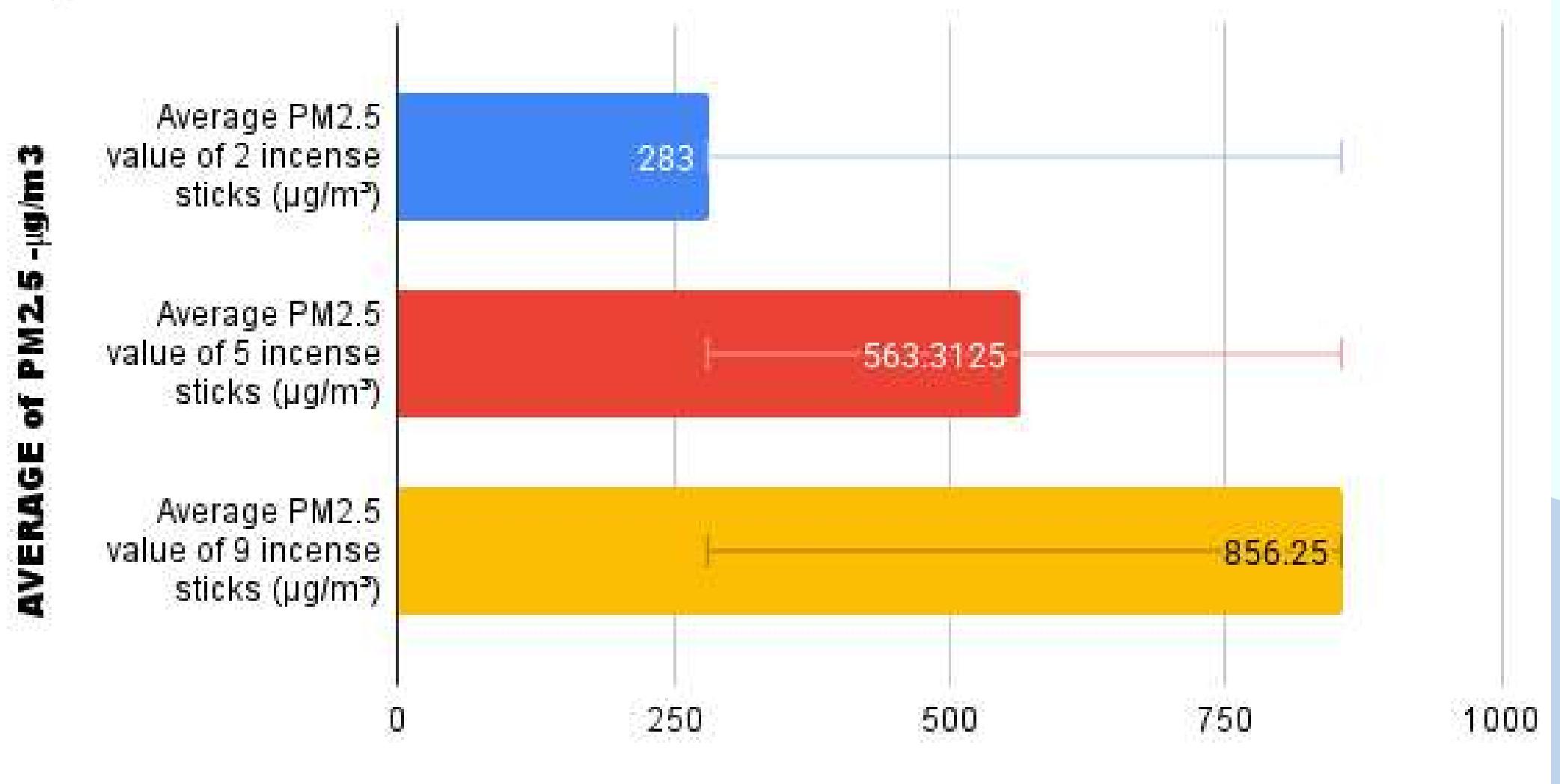


Experiment 3 – Sensor 2 (PM2.5 over 15 minutes)

- Rapid increase: PM2.5 rose sharply within the first 1–2 minutes for all groups.
- Clear dose response: 9 sticks produced the highest PM2.5, followed by 5, then 2 ($9 > 5 > 2$) at every time point.
- By 15 minutes, PM2.5 reached $\sim 1.38 \times 10^3 \mu\text{g}/\text{m}^3$ (9 sticks), compared with $\sim 8.0 \times 10^2 \mu\text{g}/\text{m}^3$ (5 sticks) and $\sim 3.9 \times 10^2 \mu\text{g}/\text{m}^3$ (2 sticks).
- Relative effect: 9 sticks produced $\sim 3.5 \times$ higher PM2.5 than 2 sticks by minute 15.
- Continued accumulation: The 9-stick curve kept increasing through 15 minutes, suggesting PM2.5 was still building up.

RESULTS - EXPERIMENT 3

Experiment 3 Sensor 2. Average PM2.5 levels for 2, 5 and 9 incense sticks

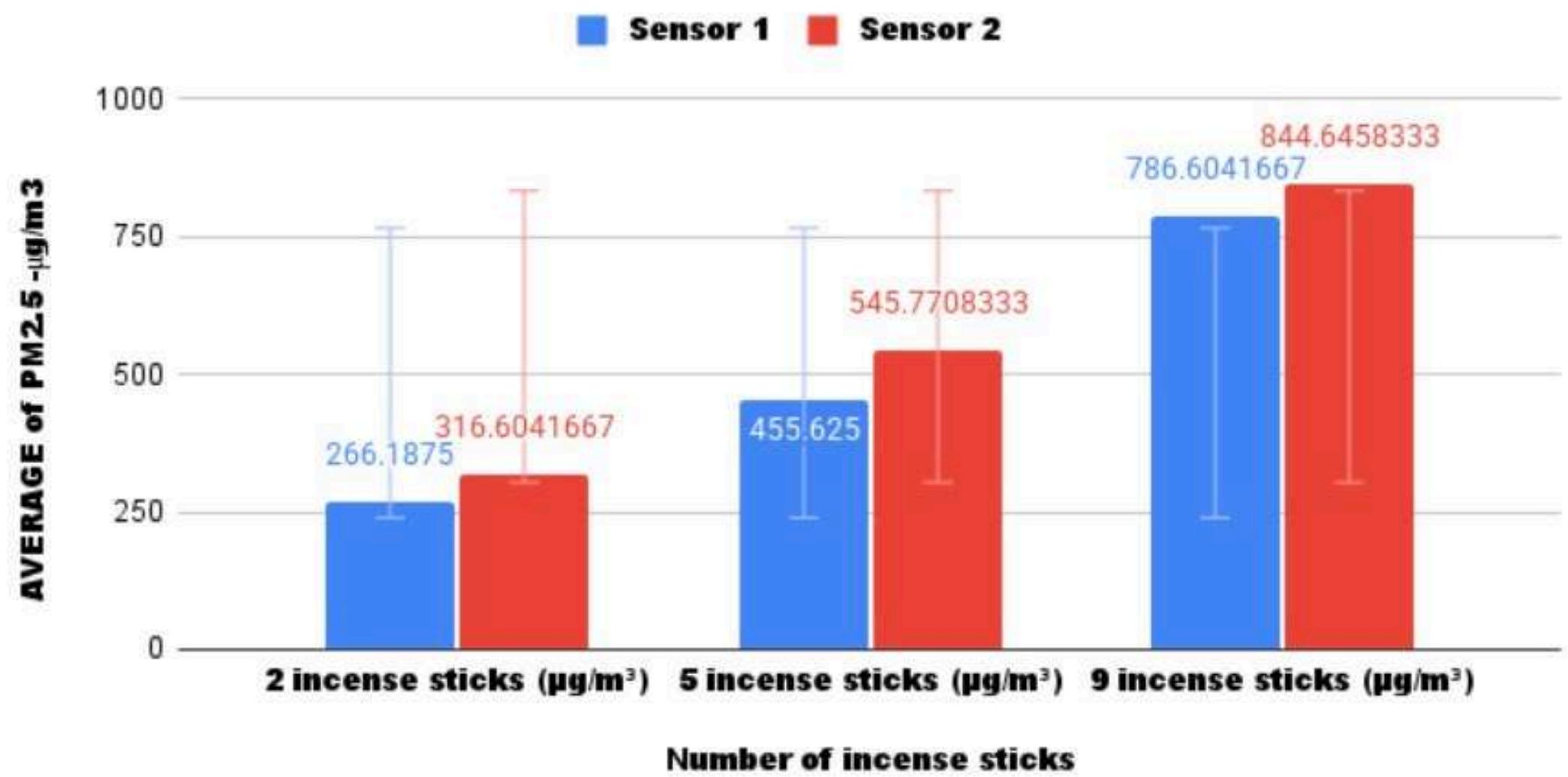


Average PM2.5 Concentration (Experiment 3 – Sensor 2)

- Mean PM2.5 increased with incense quantity ($2 < 5 < 9$).
- 9 sticks averaged $856.25 \mu\text{g}/\text{m}^3$ about $3.0\times$ higher than 2 sticks ($283 \mu\text{g}/\text{m}^3$).
- The consistent increase supports a clear dose-response relationship between source quantity and indoor PM2.5 loading.

RESULTS

Comparison of Average PM2.5 Concentrations from 2, 5, and 9 Incense Sticks Measured by Dual Sensors.

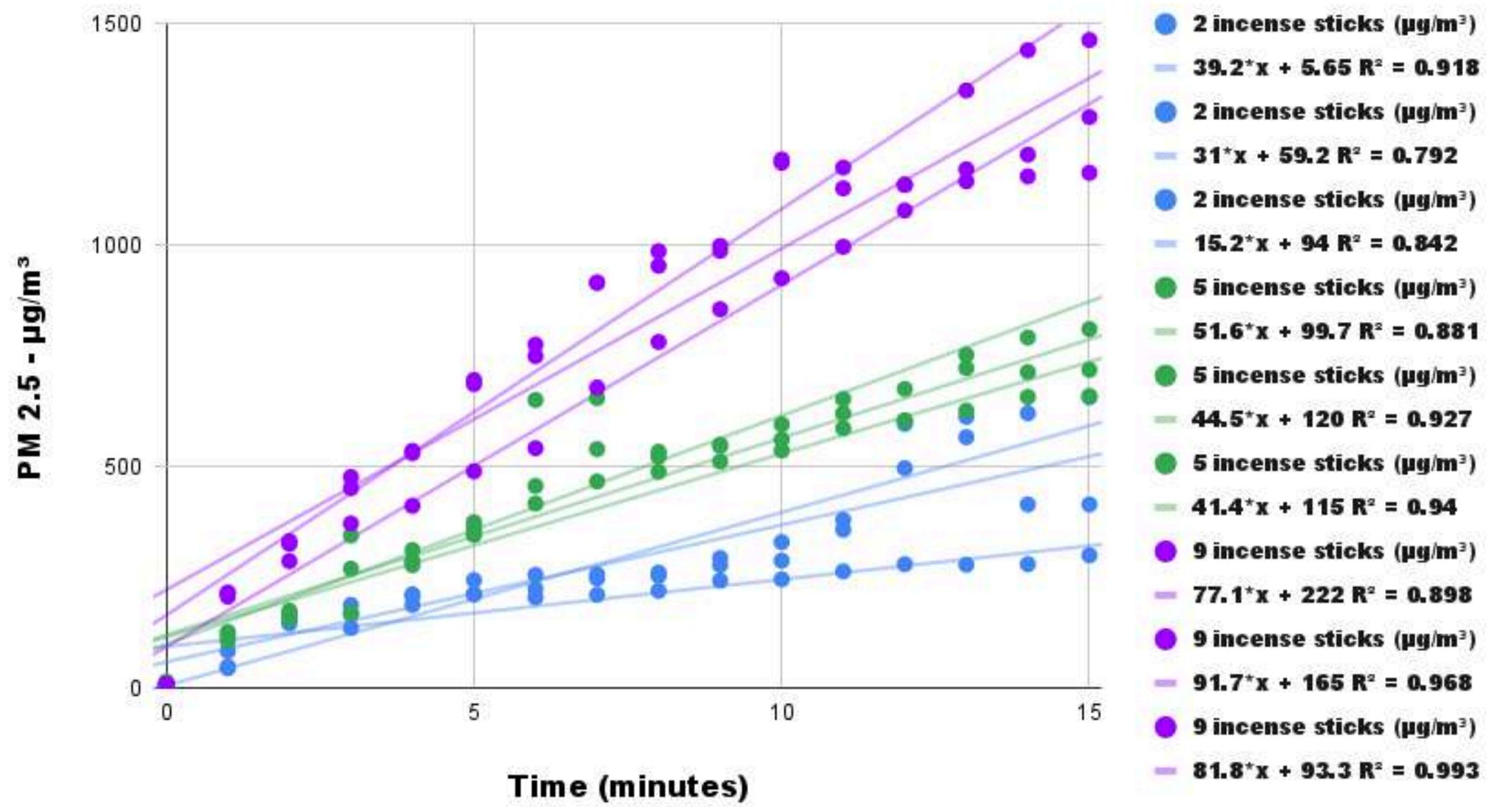


Dose response Trend: Mean PM2.5 increases with incense quantity (2 < 5 < 9) in both sensors.

- Mean PM2.5 at 2 / 5 / 9 sticks ($\mu\text{g}/\text{m}^3$):
- Sensor 1: 266.19 \rightarrow 455.63 \rightarrow 786.60
- Sensor 2: 316.60 \rightarrow 545.77 \rightarrow 844.65
- Strong Increase: 9 sticks is $\sim 2.7\text{--}3.0 \times$ higher than 2 sticks (both sensors).
- Statistical Significance (One-way ANOVA): Sensor 1 $p = 0.007$, Sensor 2 $p = 0.001$ ($p < 0.05$).

RESULTS

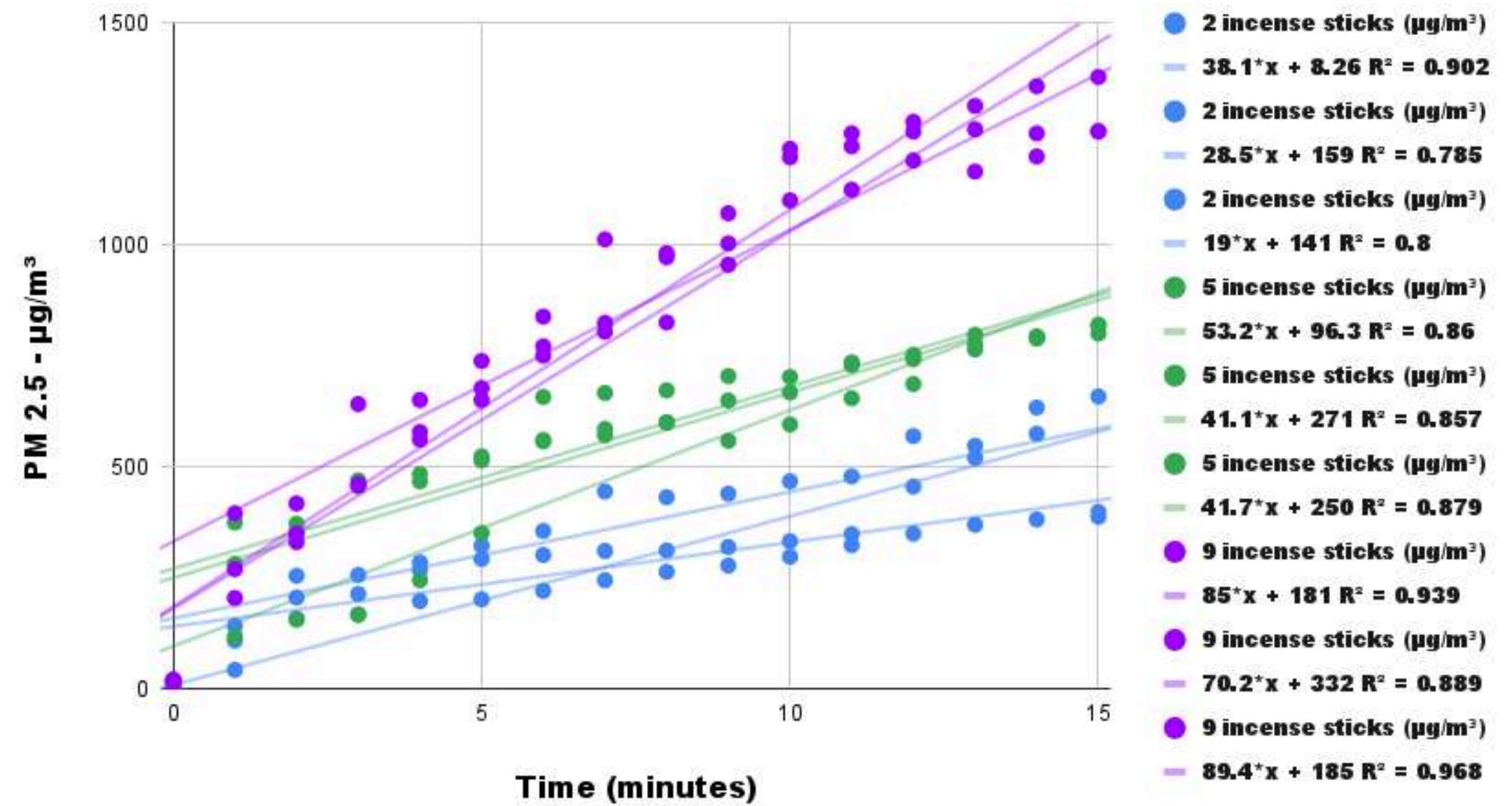
Regression Analysis of Incremental PM2.5 Loading (Sensor 1)



- Accelerated Loading Rate: Slopes rise with incense amount (2 sticks: 15.2–39.2, 5 sticks: 41.4–51.6, 9 sticks: 77.1–91.7 $\mu\text{g}/\text{m}^3/\text{min}$).
- Strong Linearity: Linear fits are high ($R^2 = 0.792$ –0.993), indicating PM2.5 increases almost linearly over 15 minutes.
- Highest Exposure Scenario: 9 sticks approaches ~1,400–1,500 $\mu\text{g}/\text{m}^3$ by 15 minutes, far above lower dose groups.
- Data Consistency: Multiple runs per group show the same upward trend, supporting consistent Sensor 1 measurements.

RESULTS

Regression Analysis of Incremental PM2.5 Loading(Sensor 2)



- **Growth Acceleration:** The loading rate (slope) increases sharply with more sticks, peaking at ~ 89.4 $\mu\text{g}/\text{m}^3/\text{min}$ for the 9 stick group.
- **Predictive Accuracy:** Strong linear fits (R^2 up to ~ 0.968) show a consistent relationship between time and PM2.5 loading.
- **Rapid Saturation:** 9 sticks drive concentrations toward $\sim 1,500$ $\mu\text{g}/\text{m}^3$ within 15 minutes.
- **Cross-Sensor Consistency:** Similar dose response trends across both sensors support overall data reliability.

CONCLUSION

- Both sensors show the same pattern: PM2.5 increases as more incense sticks are burned ($2 < 5 < 9$).
- Average PM2.5 ($\mu\text{g}/\text{m}^3$):
 - Sensor 1: 266.19 → 455.63 → 786.60
 - Sensor 2: 316.60 → 545.77 → 844.65
- One-way ANOVA confirms incense quantity significantly affects PM2.5:
Sensor 1: $p = 0.007$, Sensor 2: $p = 0.001$ ($p < 0.05$).



RECOMMENDATIONS :

- Burn fewer sticks at a time and improve ventilation (open windows / doors or burn outdoors).
- Avoid burning multiple sticks in small or closed rooms, especially around children, elderly, or people with asthma.

NEXT STEP :

Test different ventilation conditions and measure how quickly PM 2.5 drops after the incense is extinguished

VSS BADGES



I am a data scientist



I make an impact



I am a STEM professional



REFERENCES

1. He, C., Morawska, L., & Knibbs, L. D. (2014). Modification of incense smoke emissions and their impact on indoor air quality. *Atmospheric Environment*, 94, 233-239.
2. Lin, T. C., Krishnasamy, G., & Chi, D. S. (2008). Incense smoke: clinical, size-resolved, and analytical characteristics. *Clinical and Molecular Allergy*, 6(1), 3-10. <https://doi.org/10.1186/1476-7961-6-3>
3. Pollution Control Department of Thailand. (2024). Thailand Air Quality Standard for PM2.5. Ministry of Natural Resources and Environment. <http://www.pcd.go.th>
4. The GLOBE Program. (2025). GLOBE Observer: Cloud and Atmosphere Protocol. NASA. <https://www.globe.gov>
5. World Health Organization. (2021). WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide, and carbon monoxide. World Health Organization. <https://apps.who.int/iris/handle/10665/345329>

CREDIT



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THANK YOU

