Study of Particulate Matter 2.5 µm ($PM_{2.5}$) Sample Collection and Extraction Methods Suitable for Sugar Analysis

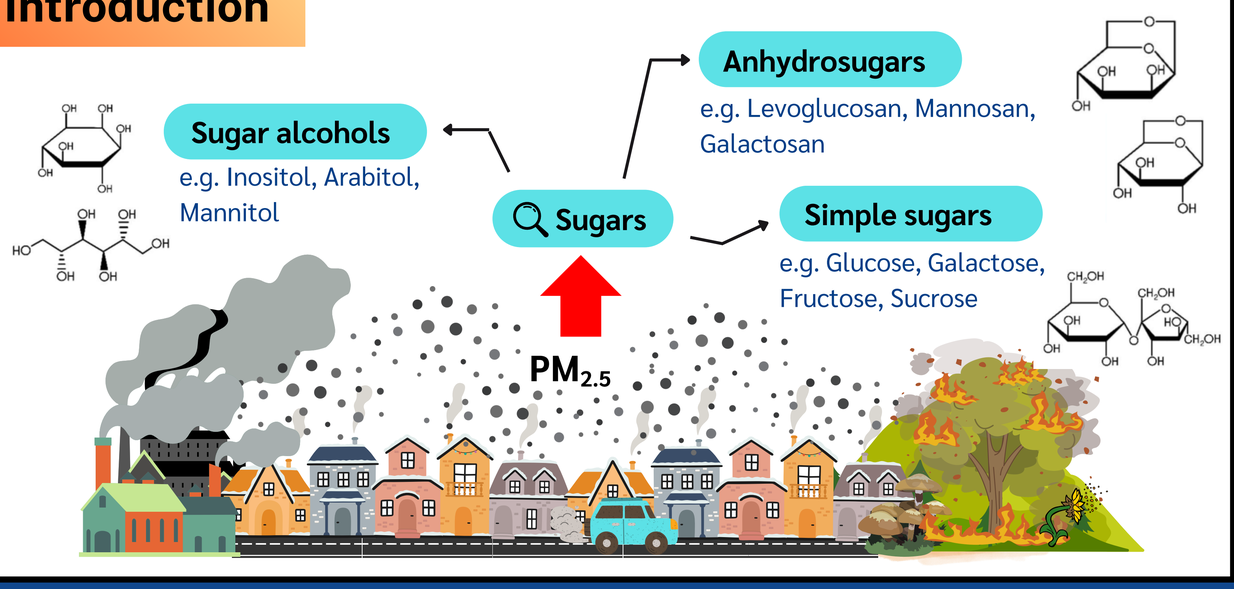
Nitiphum Noiprathom[1], Watcharapholn Harnmontree[2], Chonlada Bennett[2], Piyarat Nimmanpipug[1]

[1]Department of Chemistry, Faculty of Science, Chiang Mai University, Chiang Mai Thailand
[2]National Astronomical Research Institute of Thailand (Public Organization), Chiang Mai Thailand

Abstract

This study optimized the extraction of sugars and saccharides from $PM_{2.5}$ aerosols, essential source indicators, using deionized water as a green solvent. Samples collected at the National Astronomical Research Institute of Thailand (NARIT) were evaluated using a Taguchi L9 orthogonal array to determine the effects of temperature, time, and solvent volume. The optimal extraction conditions were identified as 35 °C, 30 min, and 15 mL, yielding a high efficiency of 98.6%. ANOVA results revealed no statistically significant differences among the tested factors ($p > 0.05$), indicating that the extraction process is robust and consistently efficient. These findings suggest that parameters can be flexibly adjusted to suit specific aerosol characteristics and analytical instrumentation without compromising recovery.

Introduction

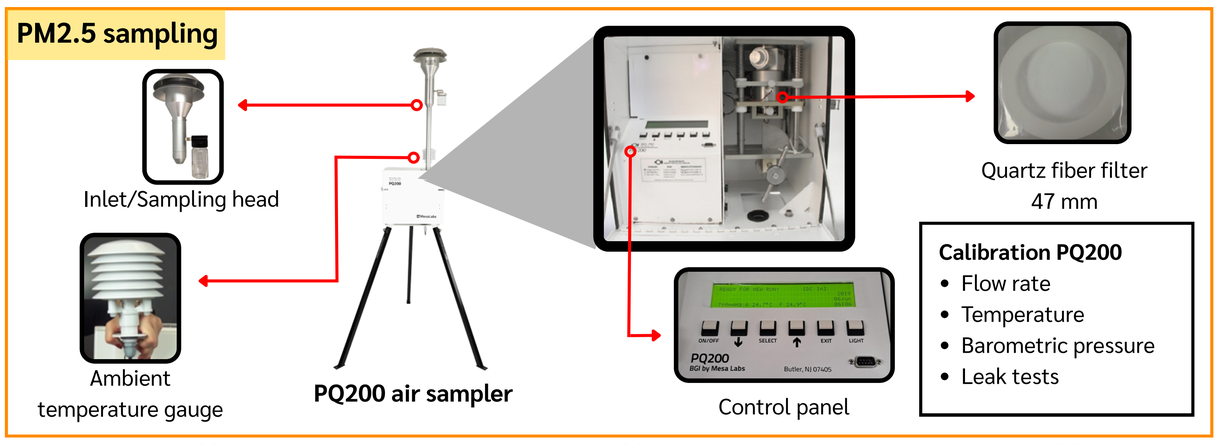


Objectives

1. To study the collection of atmospheric particulate matter using a PQ200 low-volume air sampler.
2. To study the factors influencing the extraction conditions of particulate matter from quartz fiber filters.
3. To determine the optimal extraction conditions using the Taguchi method.
4. To apply the optimal conditions to real samples collected from Chiang Mai Province.

Materials and Methods

PM2.5 sampling



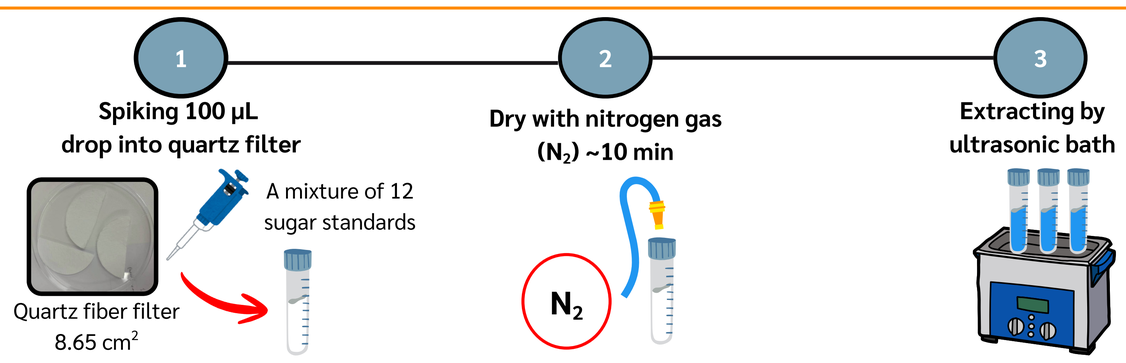


Table. 1 The 9 conditions used to determine the optimal extraction parameters using the Taguchi L9 model.

Experiments	Factorial		
	Temperature (°C)	Time (min)	Volume (mL)
1	25	15	5
2	25	30	10
3	25	45	15
4	35	15	10
5	35	30	15
6	35	45	5
7	45	15	15
8	45	30	5
9	45	45	10

$$S/N = -10\log\left(\frac{1}{n}\sum_{k=1}^{n}\frac{1}{y_i^2}\right)$$

n = Number of replicates
y_i = The observed value from experiment i

Results

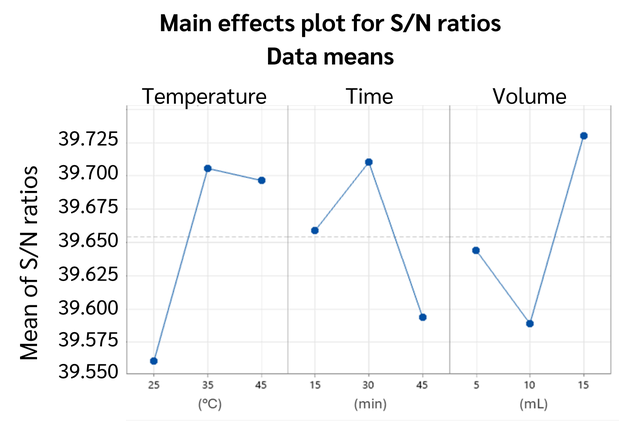


Fig. 1 Main effects plot for S/N ratios in each factors.

Table. 2 Response for S/N ratios.

Levels	S/N ratios (dB)		
	Temperature	Time	Volume
1	39.536	39.633	39.620
2	39.681	39.682	39.564
3	39.673	39.571	39.708
P-value	0.56	0.71	0.62

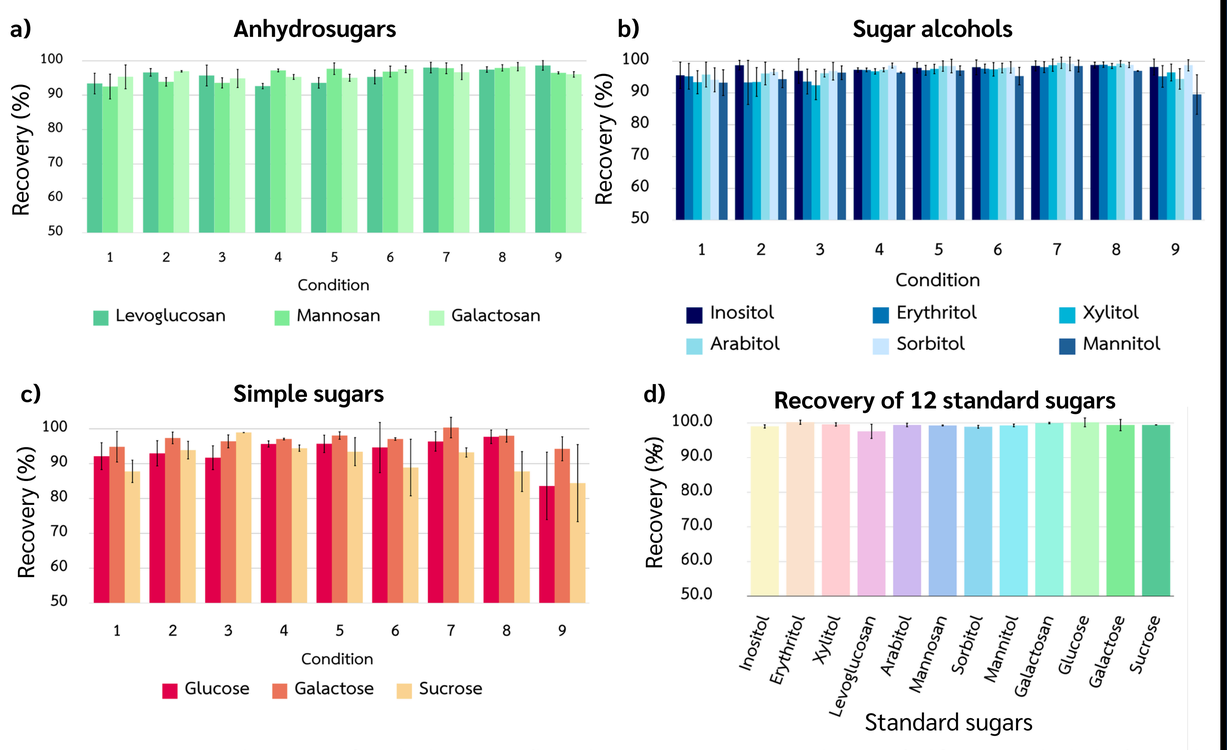


Fig. 2 Recovery of each sugars **a)** Anhydrosugars (levoglucosan, mannosan, galactosan). **b)** Sugar alcohols (inositol, erythritol, xylitol, arabitol, sorbitol, mannitol). **c)** Simple sugars (glucose galactose, sucrose). **d)** Recovery of 12 standard sugars extracted from real samples collected in Chiang Mai using the optimal extraction conditions

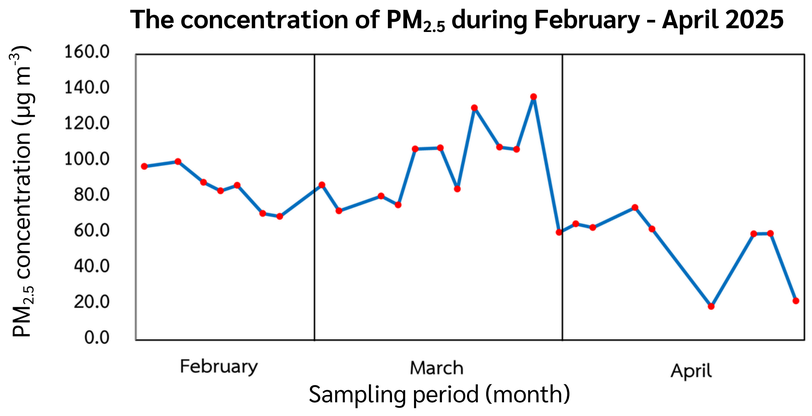


Fig. 3 $PM_{2.5}$ concentrations measured by PQ200 during February – April 2025.

Conclusion

This study identified optimal $PM_{2.5}$ sugar extraction conditions (35 °C, 30 min, 15 mL) using a Taguchi L9 array, achieving a 98.6% recovery rate. ANOVA revealed no significant differences among factors ($p > 0.05$), highlighting a robust and flexible methodology. This allows for parameter adjustments based on sample characteristics or instrument sensitivity without compromising analytical accuracy.

References

[1] Ji, Y., Li, Q., Ye, R., Tian, K., & Tian, X. (2020). The Impact of Water-Soluble Inorganic Ions in Particulate Matter (PM2.5) on Litter Decomposition in Chinese Subtropical Forests. Forests, 11, 238.
[2] Thepnuan, D., Chantara, S., Lee (2018). Molecular markers for biomass burning associated with the characterization of PM2.5 and component sources during dry season haze episodes in Upper South East Asia. Science of the Total Environment, 658, 708-722.

Acknowledgement

I sincerely acknowledge Assoc.Prof.Dr. Piyarat Nimmanpipug and CMU team for their expert guidance, facilities, and advanced analytical equipment. I am also grateful to Dr. Chonlada Bennett and the Narit team for their technical support and report reviews, as well as all colleagues for their encouragement in making this project a success.