

Measurement and Emission Characteristics of PM2.5 in Work Environments

Introduction

- PM2.5: fine particles $\leq 2.5 \mu\text{m}$, harmful to human health
- Usually low in Japan, but increases during dust, pollution, or volcanic events
- Health and economic impact: over 2% of Japan's GDP
- Past studies have reported measurements near an open window during soldering
- Quantitative comparisons between work and living environments are limited

Purpose

To measure PM2.5 concentrations in work and living environments using a self-made measurement system, and to understand their characteristics.

Experimental Method & Equipment

Sensor

- ZH03B Winsen

Sensor capacity: up to 1000 values

- Arduino UNO R3

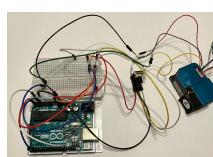


Figure 1. Components

1. Work Environment

For soldering work, PM1.0, 2.5, 10 levels were measured for 30 seconds (s) before, 60s during, and 60s after soldering



Figure 2. Measurement position during soldering

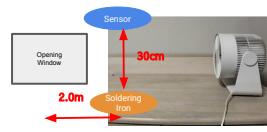


Figure 3. Measurement position during soldering with fan

2. Living Environment

We regard household chores as "work", and studied PM2.5 emissions produced by home appliances including gas grill and toasting.

To examine the relationship with the strength of ventilation, we measured 3 patterns below: After grilling/toasting bread for 3 min 30s, opening door for 30s, and after grilling/toasting for 2 more mins before reopening.

To examine the relationship with the degree of browning, we measured 3 patterns below: After grilling bread for 3 min 30s, opening door for 30s, and reopening door several times. Time until opening the grill door was extended by 15 s with each bread replacement.

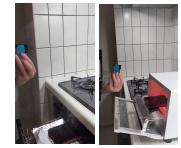


Figure 4. Measurement positions around grill and toaster

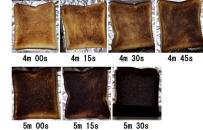


Figure 5. Degree of browning

Results

1. Work Environment

- PM2.5 values were the highest (approx. $290 \mu\text{g}/\text{m}^3$) when measured 30cm directly above the soldering activity.
- Compared to the sharp increase in PM2.5 levels during soldering with no control, with levels **rose more gradually and reached significantly lower peak values** when soldering with ventilation and fan.

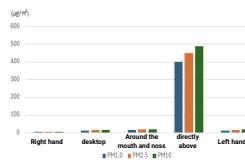


Figure 6. Comparison of average PM1.0, PM2.5, and PM10 concentrations at various locations during soldering

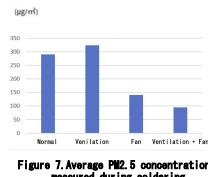


Figure 7. Average PM2.5 concentrations measured during soldering

※Ventilation: Window Open

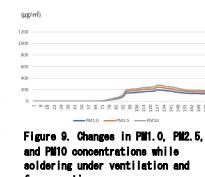


Figure 8. Changes in PM1.0, PM2.5, and PM10 concentrations 20 cm directly above the soldering iron during soldering

2. Living Environment

- The higher the ventilation fan mode, the higher the PM levels near the toaster.
- PM was detected even when butter was not heavily burnt.
- The higher the ventilation fan mode, the higher the PM levels near the grill.
- When the grill was opened at 5 mins, the value measured near the grill peaked rapidly.

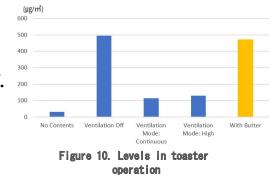


Figure 10. Levels in toaster operation

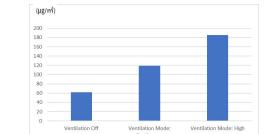


Figure 11. Comparison of PM2.5 levels in grill operation



Figure 12. Changes in PM2.5 levels with bread browning



Figure 13. Layout of kitchen

Figure 14. Condition of bread toasted with butter

Discussion

- Because of the way the smoke rises, it is dangerous to have our face 30 cm directly above the soldering iron.
- We can reduce PM2.5 exposure by using a fan and an ventilation fan, but we should avoid the airflow path.
- PM2.5 is emitted when toast is completely burnt, but it is unclear whether the PM from bread is actually harmful.

Conclusion

- Both during bread toasting and soldering → PM levels will be **higher with the vent** on than with the vent off.
- During soldering → PM levels will **change depending on the measurement position**.
- During bread toasting → PM levels **rise rapidly** when the toast is completely burnt.

Future Studies

- Expand PM2.5 level measurements to industrial tasks such as welding, lathe operation, and laser processing.
- Develop methods to measure PM2.5 levels in different rooms simultaneously for comparative analysis.

References

- 1) Public Relations Office, Graduate School of Arts and Sciences / College of Arts and Sciences, The University of Tokyo. (2025, July 28). PM2.5 Reduces Labor Supply in Japan: Empirical Evidence from Statistical and Observational Data – Air Pollution Reduction May Bring Economic Benefits. (The University of Tokyo News & Topics). <https://www.c.u-tokyo.ac.jp/info/news/topics/20250728140000.html>
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- 3) Rie Aoki, Yuko Yamamoto, Michio Kojima, Yasuko Koike, Yoshitomo Imai, Hiroko Minagawa, "Concentration of PM2.5 in room air", The Reports of the Aichi Institute of Public Health, 2017, No.67,39-47, <https://www.pref.aichi.jp/eiseiken/teikikankou/syoho67.pdf>
- 4) Natter, A. (2023, January 9). US safety agency to consider ban on gas stoves amid health fears. Bloomberg News. <https://www.bloomberg.com/news/articles/2023-01-09/us-safety-agency-to-consider-ban-on-gas-stoves-amid-health-fears>