Application of air sensors to support clean cooking initiatives at education centres in low- and middle-income countries using Accra High School, Ghana as a case study.

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Abstract

Majority of the senior high schools in Ghana with boarding facilities employ kitchen staff for cooking and food vending. The staff, predominantly women rely on solid fuel for cooking and heating. Till date, there's no evidence on the extent to which kitchen staff are exposed to fine particles, one of the major contributors to air pollution induced premature deaths globally and a major health risk factor for pregnant women and their fetus. We employed appropriately calibrated micro Airnote $PM_{2.5}$ (Blues Wireless, USA) monitor at the Accra High School in the Greater Accra Region of Ghana to understand this phenomenon.

Measurement Interests

Desired Attribute	Airnote Monitor	Remarks
Measure $PM_{2.5}$ episodes	?	Performance characteristics of the Airnote Monitor at higher source of $PM_{2.5}$
Meaningful $PM_{2.5}$ data	?	Ability to generate meaningful data to support clean cooking initiative
Support long-term monitoring	?	Establish the potential of long-term monitoring to track clean cooking initiatives

Field Measurements

This is an ongoing project, but the data presented here is from June 01, 2023, to February 06, 2024. The correction factor applied in this work can be found here (Hodoli et al., 2024 *under review*).

Field deployment of micro Airnote $PM_{2.5}$ air sensor at Accra High School (Kitchen)

Conventional cooking & heating method with solid fuel

Hon. Dr. Zanetor Agyeman-Rawlings presenting on clean cooking

Retrofitted cookstove to support the clean cooking initiative

Conclusion and implications

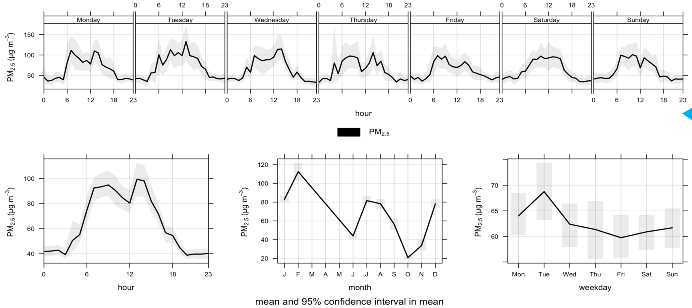
This study illustrates the usefulness and application of air sensors to support clean cooking initiatives in environments with poor energy sources for cooking and heating. This is a directly reproducible approach which is possible to implement across many areas of continental Africa. We recommend the implementation of continuous air quality measurements at and around cooking areas to understand the impacts of newer and more efficient cooking appliances on local air quality. We also recommend the use of the data for air pollution and sustainability science education at the Accra High School or in similar settings with air sensor campaigns.

Literature cited

Giordano, M. R., Malings, C., Pandis, S. N., Presto, A. A., McNeill, V. F., Westervelt, D. M., Beekmann, M., & Subramanian, R. (2021). From low-cost sensors to high-quality data: A summary of challenges and best practices for effectively calibrating low-cost particulate matter mass sensors. *Journal of Aerosol Science, 158*, 105833. https://doi.org/10.1016/j.jaerosci.2021.105833.

Hodoli, C. G., Coulon, F., & Mead, M. I. (2023). Source identification with high-temporal resolution data from low-cost sensors using bivariate polar plots in urban areas of Ghana. *Environmental Pollution, 317*, 120448. https://doi.org/10.1016/j.envpol.2022.120448.

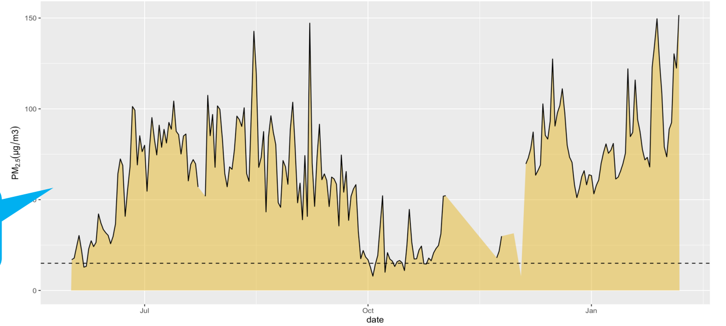
Measurement Results



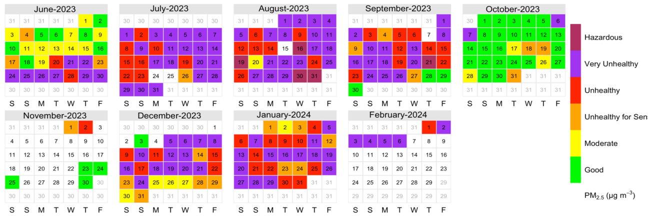
Diurnal cycle plot for $PM_{2.5}$ at Accra High School where the top panel shows hour/day, left bottom panel shows hour, middle bottom panel shows month and right bottom panel shows day of the week with *ci*

- Observed $PM_{2.5}$ at the kitchen area were ten times higher (150 μgm^{-3}) than the recommended WHO AQG threshold of 15 μgm^{-3}.
- These levels dropped in October to a little below 15 μgm^{-3} but peaked again from December (~75 μgm^{-3}).

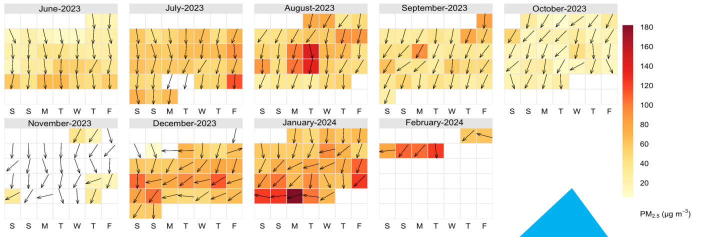
- We observed consistency between elevated $PM_{2.5}$ levels (100 μgm^{-3}) and cooking hours between 06:00 hrs and 18:00 hrs each day.
- $PM_{2.5}$ levels dropped in October to 20 μgm^{-3} due to holidays and with a sharp increase in November to 40 μgm^{-3}.
- We observed the harmattan effect which contributed to elevated $PM_{2.5}$ levels in the from December to February (also visible in the calendar plot in the function of wind direction).



Reported 24-hour $PM_{2.5}$ levels against WHO Air Quality Guidelines threshold of 15 μgm^{-3} for $PM_{2.5}$ exposure with the *dashed line* showing the WHO threshold.



- Calendar plot using the Air Quality Index showed that the kitchen staff are exposed to unhealthy, very unhealthy and hazardous levels of $PM_{2.5}$.
- Also, nearly 74% of the reported $PM_{2.5}$ data in October were good for outdoor activities.



- Calendar plot for $PM_{2.5}$ in the function of wind direction; apart from December 2023 to February 2024, dominant wind direction influencing $PM_{2.5}$ pollution at the site were driven by Northerly winds.
- The change in wind speed-direction were due to the harmattan which is experienced in Ghana during that time of the year (late November to March).

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