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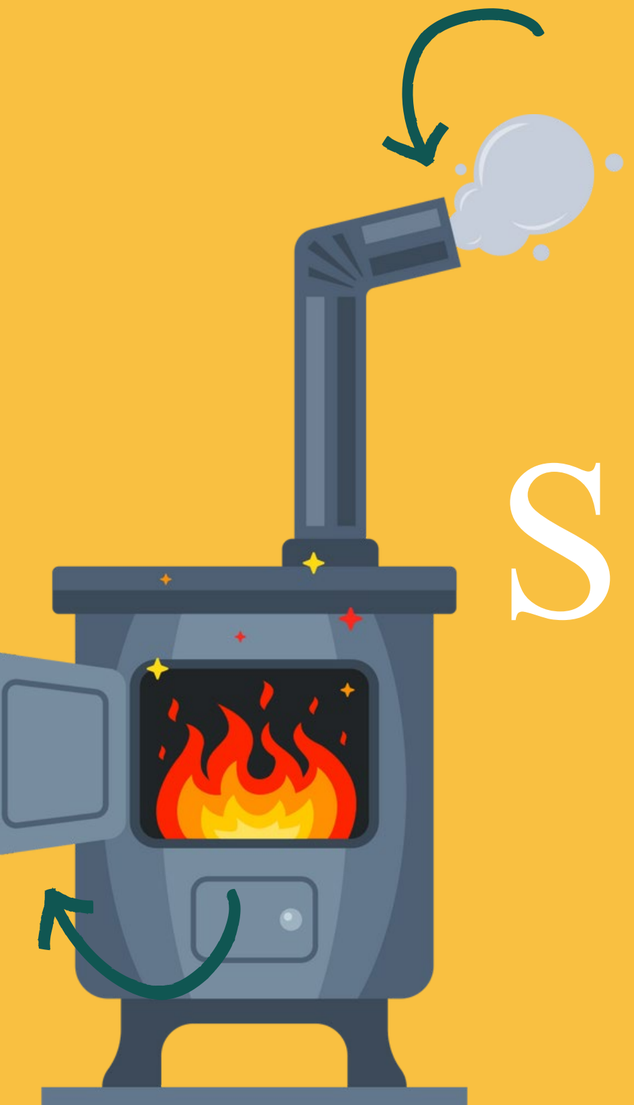

WOOD STOVES: COZY FIRE OR STEALTHY SMOG?

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About Me

ROHIT CHAKRABORTY

B.ENG, MSC (QUB, Belfast),
PHD (UoS)
AIR QUALITY SCIENTIST, AIRRATED

I did a PhD (2018-2022) from University of Sheffield, on air pollution minoitoring and modelling in cities using Low cost sensors, followed by joining AirRated as an Air Quality Scientist.

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Open Access Article

Indoor Air Pollution from Residential Stoves: Examining the Flooding of Particulate Matter into Homes during Real-World Use

by Rohit Chakraborty [1,*], James Heydon [2], Martin Mayfield [1] and Lyudmila Mihaylova [3]

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https://www.mdpi.com/2073-4433/11/12/1326

Wood burners triple harmful indoor air pollution, study finds

Exclusive: Burners should be sold with health warnings, say scientists who found tiny particles flooding into rooms

https://www.theguardian.com/environment/2020/dec/18/wood-burners-triple-harmful-indoor-air-pollution-study-finds

OBJECTIVES

LOW COST SENSORS

- Can low cost sensors (LCS) be reliably used to measure indoor AQ exposure in real world?
- What's the impact of LCS?
- Data driving impact and behaviour?

REAL-WORLD INDOOR PM

- It presents a framework in order to determine real-world indoor PM exposure from the use of residential heating stoves.
- Detect and identify the existence of peak indoor PM2.5,PM1, and PNC levels as a result of stove use.

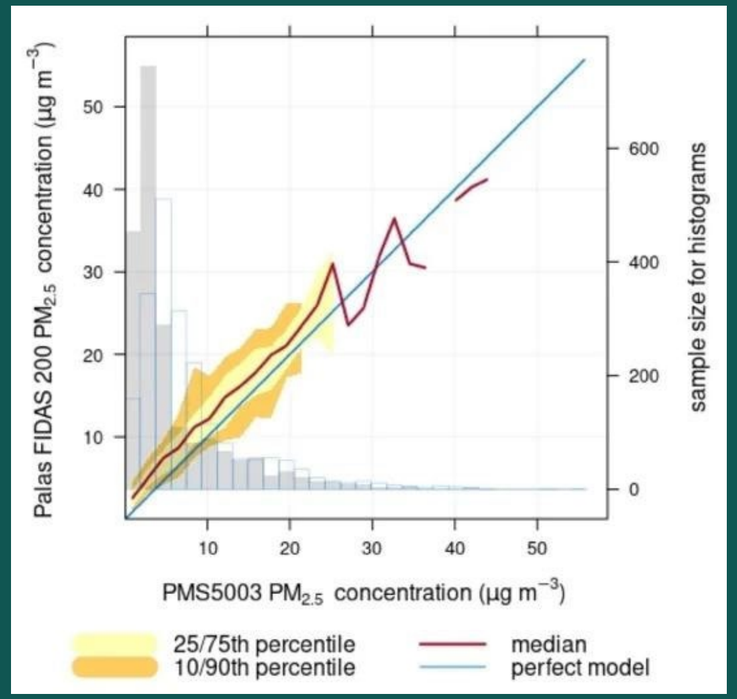
DEFRA REGULATIONS

"SMOKE EXEMPT APPLIANCE"

Health risks posed during normal operation and, in turn, whether DEFRA testing standards need modification in light of this reality.

Methods

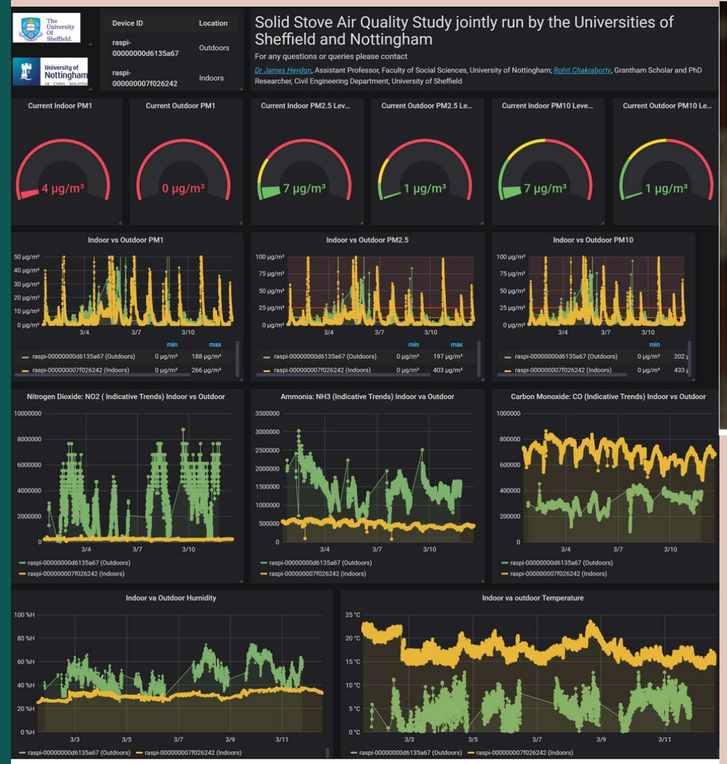
ACCURACY



DAQI	1	2	3	4	5	6	7	8	9	10
Band	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very High
µgm^{-3}	0–11	12–23	24–34	5–41	42–46	47–52	53–58	59–64	65–69	70 or more
R^2	0.82	0.79	0.81	0.83	0.81	0.82	0.79	N/A	N/A	N/A

MONITORING

- PM sensors placed indoors in the vicinity of 20 different stoves and outdoors, recording over four weeks.
- Participants also completed a research diary providing information on time lit, amount and type of fuel used, duration of use, etc.



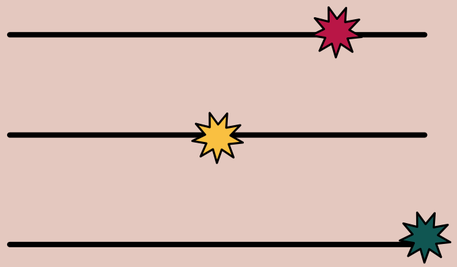
RESULT

On average, stoves were used for a duration of approximately 4 hours, with most households using their stove between 6 pm and 10 pm; during which about 9.07 pieces of fuel were consumed. The peak concentrations of PM2.5 and PM1 were observed to be 27.34 µg/m³ and 19.44 µg/m³ respectively, while the mean concentrations of PM2.5 and PM1 were 12.21 µg/m³ and 8.34 µg/m³ respectively. Additionally, an average of 10.37 pieces of kindling was used.

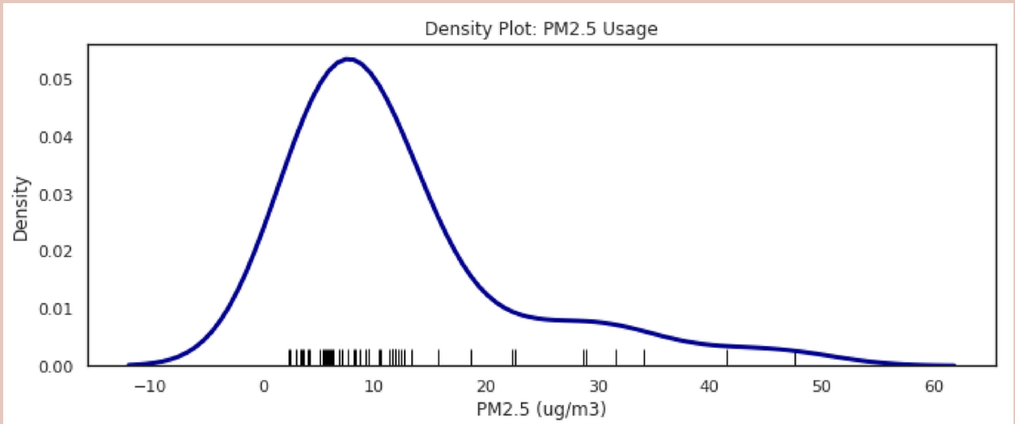
PM2.5

PM1

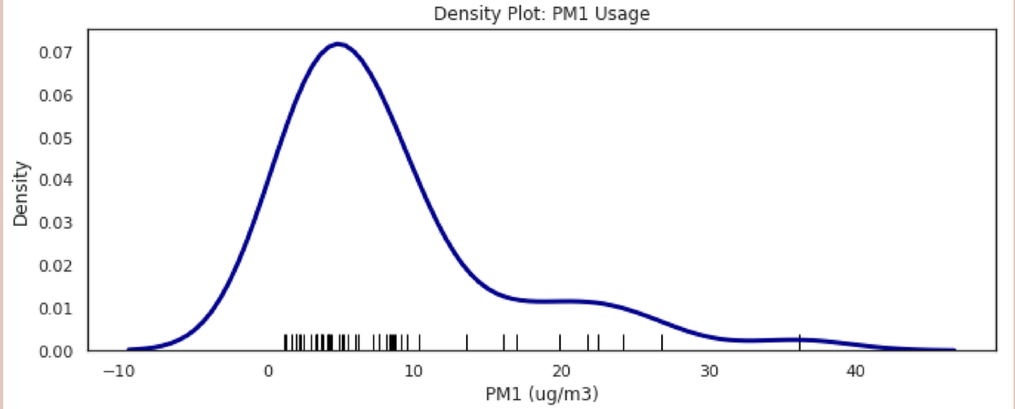
PNC



Result 1



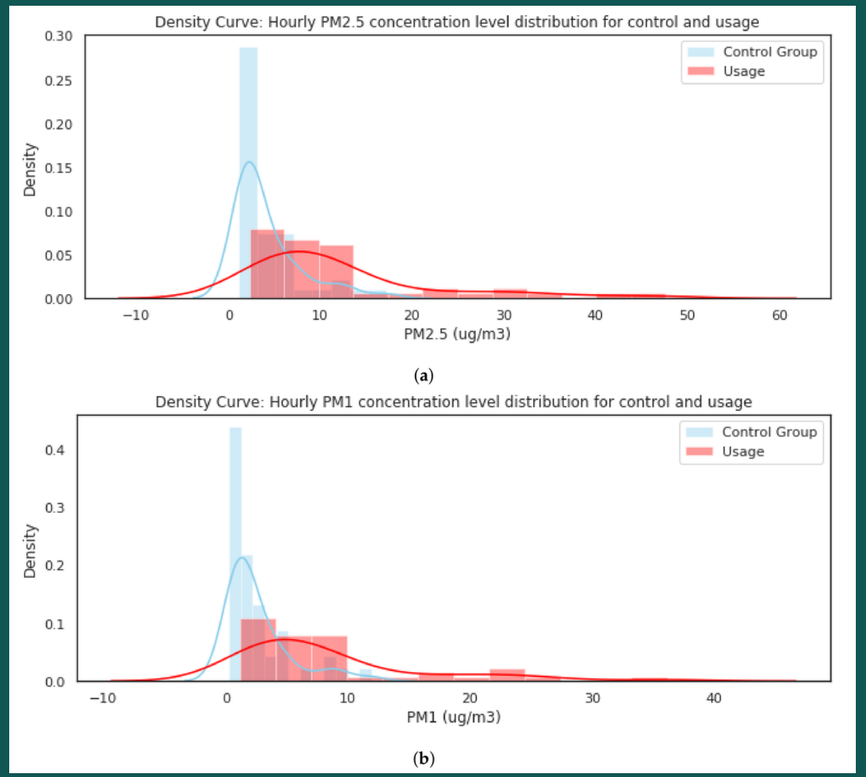
(a)



(b)

Dramatic Spike when Refueling

- Average indoor PM2.5 levels soar by a whopping 196.23%, while PM1 levels skyrocket by 227.80%.
- Some users are exposed to peak PM2.5 levels reaching an alarming 160 µg/m³.
- When stoves are in use, PM2.5 levels increase by 432.91% and PM1 levels by 281.22% compared to non-usage days.



Result 2

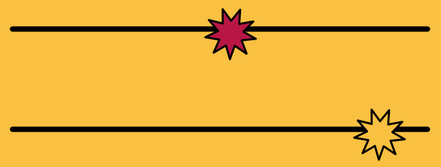
BOTTOM LINE, STOVE USE SIGNIFICANTLY COMPROMISES INDOOR AIR QUALITY, AND CALLS F IMMEDIATE INTERVENTIONS.

Hourly Peaks vs. Daily Averages in PM Levels

FLOODING OF PM INDOORS

PM2.5

PM1



- A strong correlation (r = 0.75) between hourly peak PM2.5 and PM1 and daily mean PM2.5 and PM1.
- Hourly peak mean PM2.5 (27.34 µg/m³) and PM1 (19.44 µg/m³) tower over daily mean PM2.5 (12.21 µg/m³) and PM1 (8.34 µg/m³) by an astonishing 123.91% and 133.09% respectively.

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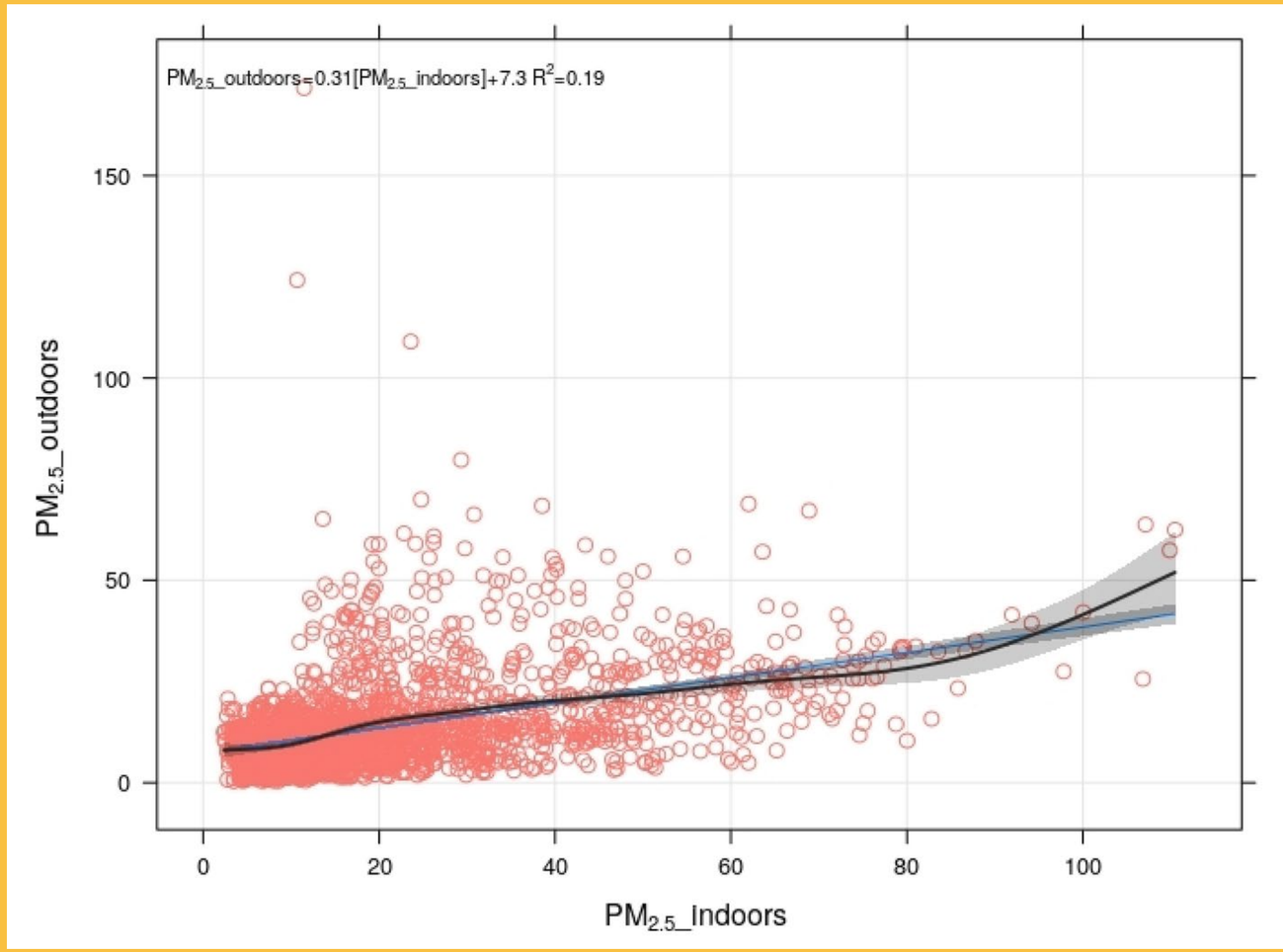
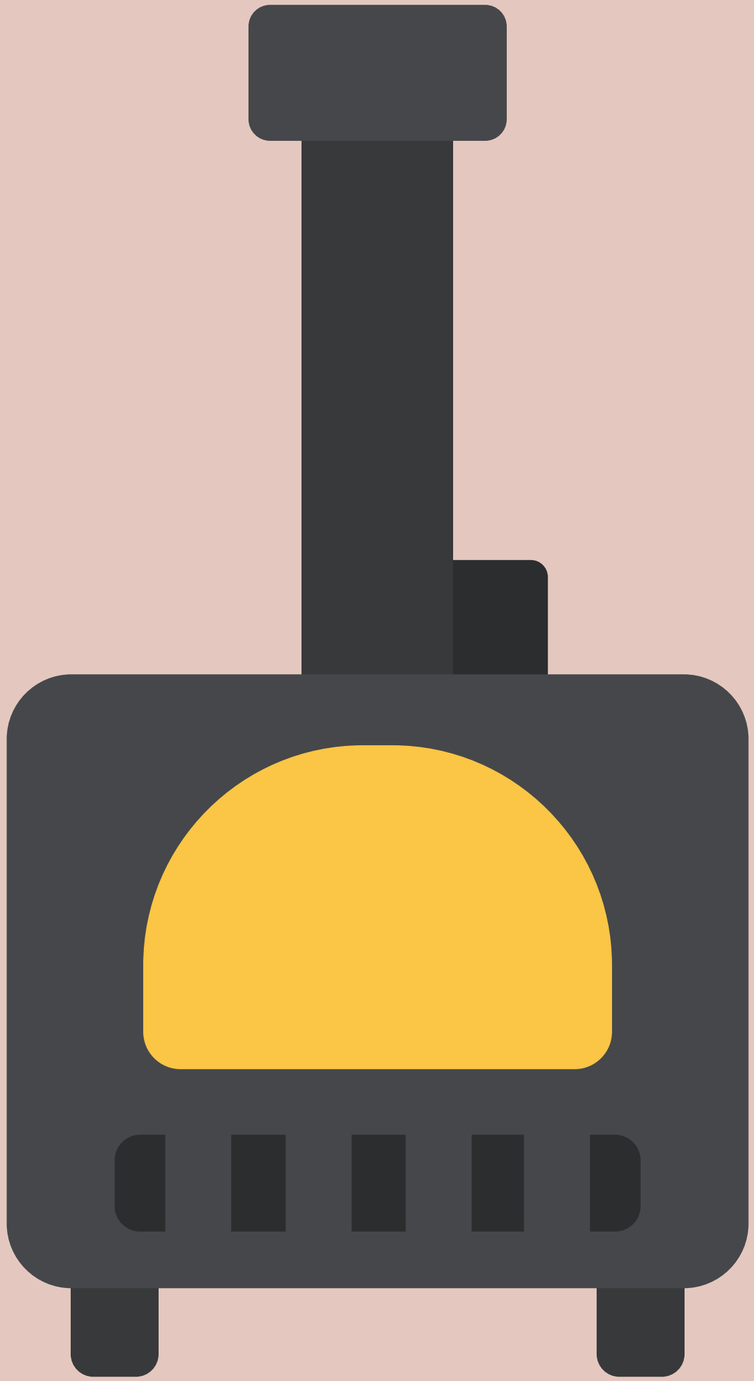
INDOOR VS. OUTDOOR AIR QUALITY

- The variation in indoor and outdoor values is considerable, especially between 10-45 µg/m³ concentration levels. Indoor levels steal the show by being significantly higher.
- Weak correlation (R^2 = 0.19) between indoor and outdoor PM2.5 levels indicates that outdoor air quality isn't the culprit behind the elevated indoor pollution.
- While indoor PM2.5 levels could impact outdoor air, this study didn't measure chimney/flue emissions. Future investigations are needed to unveil the influence of indoor pollution on outdoor air quality.



Result 3

PEAKS MATTER



MISSED IN ACTION

- Policymaking and studies largely overlook short-term PM peaks!
- Cold Stark Data

Hourly averages have been the focal point, leaving short-term high exposures under the radar. This can lead to an underestimation of potential health risks.

CALL TO ACTION

- Let's Uncover The Hidden Risks!

This study urges the scientific community to intensify indoor AQ standards on short-term peak PM exposure. increased risks.

BURNERALERT.ORG

To create a regulatory tool - First of its kind in the UK.

https://www.theguardian.com/environment/2022/jan/28/what-can-cities-do-when-air-pollution-soars-and-what-works by Dr Gary Fuller

2021

Wood burners triple harmful indoor air pollution.
Chakraborty

2022

Wood burning stoves, participatory sensing, and 'cold, stark data'
Heydon, J., Chakraborty, R.
https://doi.org/10.1007/s43545-022-00525-2

2023

Burner Alert v1 Sheffield
v2 National

Spatiotemporal Model Evaluation

- Several ML and Statistical temporal forecasting models were evaluated on a deployed and calibrated low cost sensor network, with RNN-LSTM (MAE 3.8) coming on top with GRU (MAE 3.7).
- A multi step hybrid ConvLSTM Model was created based on low cost sensor network to create a spatiotemporal forecasting model. Gaussian Model quanitification and uncertainties calculated independently for LCS.

For the current v2 national level, harnessing ground-based observations governmental sites, extensive traffic data , and comprehensive meteorological data, Burner Alert's machine learning algorithm provide post code wise pm levels and comes with further instructions.

SHEFFIELD

More than 200 sensors were deployed in Sheffield through citizen science workshops and Urban Flows Network at University of Sheffield

AirRated™

University of Sheffield

Rohit Chakraborty

CONCLUSION

- PM levels flooding indoors when refuelling by up to 400% during use, exposing homes to an invisible cloud of particles
- PM hurricane when door ajar, peaking at nearly 10,000 particles/0.1L!
- Stove designs and DEFRA's standards need a rekindle ultimately leading to a complete ban.

THANK YOU ☺

Clean Air Programme