open-seneca: development of a low cost air quality sensor network and its implementation to measure PM2.5 powered by citizen science

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Introduction

The world's urban population has grown rapidly, with urban pollutants from motor vehicles, construction, and industrial facilities being the sole cause of many health problems we experience today. Most of these pollutants are not visible, so monitoring is essential. 7 million deaths have been attributed to air pollution, 80% of which have been connected to PM2.5.

The combination of open-source, low-cost, air quality sensors, together with a citizen science approach for data collection, has shown the potential to obtain air pollution data with a spatial and temporal resolution un-achievable by reference stations. The data from such approaches provide a rich depth of information, which could be used to drive urban planning and policy towards creating a healthier environment.

Reference station	Citizen science
+ Accurate	+ Low cost
– Expensive	+ High spatial/temporal resolution
– Stationary	+ Engaging and educational
	+ Enables identification of pollution hotspots
	– Individual sensors lack accuracy

The design of a mobile PM2.5 air quality sensor with a total cost below £100 per unit is presented here, together with the implementation and results of a citizen science sensor network of 20 sensors monitoring PM2.5 in Buenos Aires, Argentina. Insights on the added value of citizen engagement are also outlined.

Methodology

Figure 1 Stages of a citizen science project.

Workshops at 2 local universities to 80+ students:
- 1 hour lecture on air pollution and health
- Introduction to sensing method and sensor
- Building sensors in groups of 4-5

Data collection over 7 weeks:
- Sensors placed on bikes, measuring every 5 s
- 20 chosen citizen scientists out of 70 applicants
- Citizen scientists chosen based on the amount and where they cycled in Buenos Aires
- Data uploaded by citizen scientists onto an online, interactive platform

Evidence based policy:
- Aggregated data processed
- Results passed onto local policy makers

Acknowledgements

All our citizen scientists

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Mobile air quality sensors

- Off-the-shelf components interfaced with a 'plug & play' style PCB.
- Low cost PM2.5 sensor based on laser light scattering principle.

Figure 2 open-seneca mobile air quality sensor.

Pollution maps

20 · 3,500 km · 15,000 mins · 440,000 pts

Method of identifying hotspots:
- Aggregation of collected data
- Removing time varying baseline over fixed time period (15 minutes chosen), using different measures of centre
- Build map of baseline removed dataset, taking the average PM2.5 value within fixed quadrant sizes (200 m × 200 m chosen)

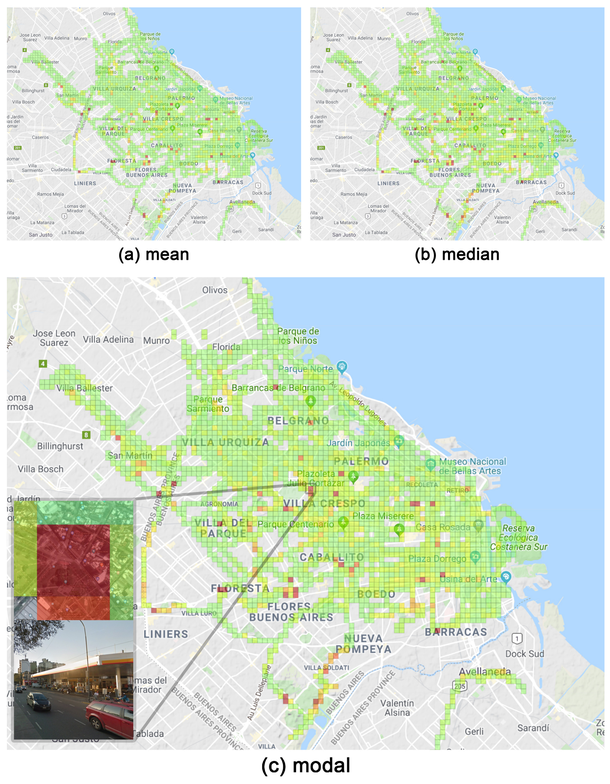

Figure 3 Identification of pollution hotspots using different measures of centre. Red indicates 30 µg/m^3 or above the baseline. Green indicates at or below baseline.

- PM2.5 distributions over 15 minute periods were approximately log-normal. Either modal or median as a measure of centre were found suitable for the identification of pollution hotspots.

Calibration

- 6 mobile sensors placed by reference station over 15 hour period.
- All mobile sensors were consistent within ± 2 µg/m^3.

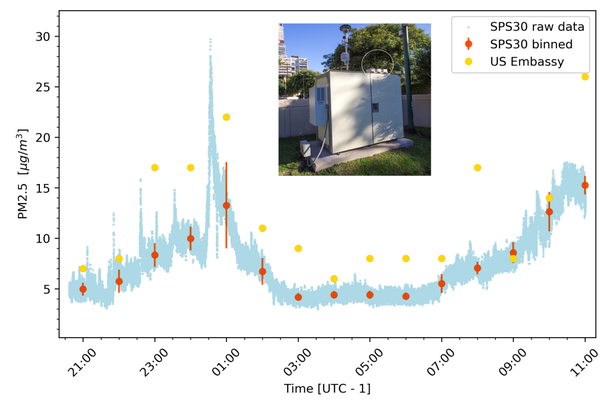

Figure 4 Comparison of all 6 sensor readings and reference station hourly readings.

- Over 7 week pilot period, hour medians of sensor data were compared to same reference station.

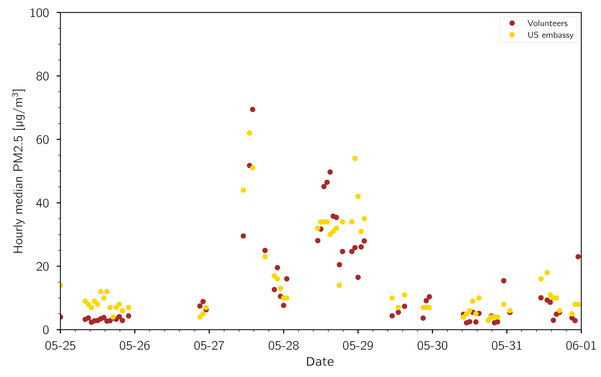

Figure 5 Comparison of hourly medians from all active sensors during 1 week period.

Citizen Engagement

- Each ride was viewable in the form of a time-series plot or via an interactive map.

Figure 6 Online interface for citizen scientists.

- Engaged citizens are involved as active stakeholders and local champions.

Figure 7 Collaborators in Nairobi.

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