**Smart approaches for using portable sensors in air quality research**

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Research sponsored by
For regulatory purposes

Criteria pollutants

- CO • TSP
- SO₂ • PM₁₀
- O₃ • PM₂.₅
- NO₂ • Pb

Real exposure might be different than reported by ambient monitoring stations
Passive samplers

- Preparation
- Extraction
- Filtration
- Chemical analysis

Preparation → Extraction → Chemical analysis → Filtration
**Electrochemical cells**

**O₃ electrochemical sondes**
- Preparation one day before elevations
- Response test (Ozonizer KTU-2)
- Calibration after every elevation (standard UV O₃ monitor, API-400)
- Data post-processing

**Measurements: 2001-2004**

Portable & battery operated sensors

- PM$_1$, PM$_{2.5}$, PM$_{10}$
  - DustTrak TSI 8534
- Particles # Conc.
  - CPC TSI-3007
- Black carbon
  - MS AE51
- CO$_2$
  - LI-840 & CR1000
- CO
  - Langan T15n
- Position
  - Garmin GPS

- Photoelectric Aerosol Sensor & Diffusion Charger
  - PAS 2000CE & DC2000CE
- pPAHs & Active Surf. Area
  - Portable & battery operated sensors

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SMART
NUS
ETH Zürich (SEC) SINGAPORE-ETH CENTRE

Measurements along Little India streets
Instruments validation

$\text{Micro-Aethalometer} = 0.87$

$r^2 = 0.87$
### Transport/Background concentrations

<table>
<thead>
<tr>
<th>Method</th>
<th>PM&lt;sub&gt;2.5&lt;/sub&gt;</th>
<th>Part. #</th>
<th>PM&lt;sub&gt;2.5&lt;/sub&gt;</th>
<th>Part. #</th>
<th>Black carbon</th>
<th>pPAH</th>
<th>PM&lt;sub&gt;2.5&lt;/sub&gt;</th>
<th>Part. #</th>
<th>Black carbon</th>
<th>pPAH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>1.16</td>
<td>1.32</td>
<td>0.78</td>
<td>0.64</td>
<td>0.58</td>
<td>0.80</td>
<td>0.38</td>
<td>0.32</td>
<td>0.28</td>
<td>0.39</td>
</tr>
<tr>
<td>MRT</td>
<td>1.08</td>
<td>0.66</td>
<td>0.73</td>
<td>0.32</td>
<td>0.35</td>
<td>0.30</td>
<td>0.39</td>
<td>0.17</td>
<td>0.19</td>
<td>0.16</td>
</tr>
<tr>
<td>Taxi</td>
<td>1.10</td>
<td>1.41</td>
<td>0.76</td>
<td>0.69</td>
<td>0.58</td>
<td>0.87</td>
<td>0.45</td>
<td>0.42</td>
<td>0.34</td>
<td>0.52</td>
</tr>
<tr>
<td>Walking</td>
<td>1.47</td>
<td>2.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Transport/Walking concentrations

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You know now how to commute
Aerosol pollution at bus stops

PM$_{2.5}$ > 4-5 @ambient level

> 95% PM$_{10}$ → PM$_{2.5}$

26 nm

Diameter average surface

> 60%
**Khlong boats, Bangkok, Thailand**

<table>
<thead>
<tr>
<th></th>
<th><strong>Pier</strong></th>
<th><strong>Inside the boat</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Black carbon (µg m⁻³)</td>
<td>74 – 136</td>
<td>15 - 411</td>
</tr>
<tr>
<td>PM₂.₅ (µg m⁻³)</td>
<td>110 – 200</td>
<td>295 – 1,470</td>
</tr>
<tr>
<td>Equivalent sound level (dBA)</td>
<td>70 - 78</td>
<td>83 - 95</td>
</tr>
</tbody>
</table>

Data-driven modeling to analyze air pollution data at street level

Spatial distribution of PM$_{2.5}$ at Little India

Evening rush hour (18-20 h) Weekdays

- Average: 31 µg m$^{-3}$
- 10% of the cells < 25 µg m$^{-3}$ (24-h WHO)
- Only 2 cells < 19 µg m$^{-3}$ (background)
Design of a monitoring network at street level

Grid cells colored more intensely represent better their corresponding clusters

- Best locations
Citizen science

Seeeduino sensor
- Temp. & Hum.
- Light
- Sound
- Air quality
- Dust

98 sensors
7 cities
- Boston
- San Francisco
- Geneva
- Rio de Janeiro
- Shanghai
- Bangalore
- Singapore

10-sec readings

Supported by: swissnex

http://datacanvas.org/
Citizens don’t create hypothesis
don’t design experiments
don’t follow the scientific method
For personal use

TZOA Wearable Air Quality Tracker

$124

Three to take away

http://www.mytzoa.com/#homepage
Real time air quality maps

People will make informed decisions about their daily lifestyle and mobility patterns.

AIRSCAPES SINGAPORE

- Temp.
- Pressure
- RH
- CO
- NO₂

{Pollutants under control}

Sensors still no validated

http://137.132.22.82:15059/
Accurate, high-quality data take time and money to collect and process

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