Practical challenges of using PurpleAir-II-SD Low-cost sensors for Air Quality Monitoring in sub-Saharan Africa

Air Sensors International Conference - 11 May 2022

Dr Babatunde Awokola, PhD student (Babatunde.Awokola@lshtm.ac.uk)
The Gambia... Smiling Coast of Africa
I have no disclosures to make

I do not have any conflict of interest
Background

• The future of citizen science and widespread air quality measurement in sub-Saharan Africa and other resource-constrained settings lies in the successful deployment of low-cost sensor networks.

• As attractive as this prospect is, the deployment of the latter is fraught with challenges that affect the overall aim of continuous air pollutant measurement.

• We report the practical challenges we experienced during the pilot project “Measuring Air Quality in Africa for Advocacy” (MA3) in seven African countries.
The MA3 Consortium

- Initiative of the MA3 Consortium (ACCA, LSTM, Lancaster University, University of Stirling)
- Exposure scientists from nine different countries in sub-Saharan Africa
- Sole goal is to organize a network of low-cost sensors for continuous Ambient PM$_{2.5}$ measurement in urban cities in SSA
- Launched in May 2019 at Pan African Thoracic Society MECOR course in Dar Es Salaam, Tanzania. Training was facilitated by Dr Gabriel Okello, Prof Sean Semple & myself.
MA3 Participating Countries

Ambient PM$_{2.5}$ to be collected by 15 Exposure Scientists from 9 countries trained in air quality monitoring under the measuring air quality for advocacy initiative (MA3).
Methodology

• PurpleAir-II-SD devices were given to 15 participants at an AQM workshop. Thirteen exposure scientists from seven countries (Gambia, Kenya, Uganda, Benin Republic, Burkina Faso, Cameroon and Nigeria) eventually installed the instruments and participated in pilot data collection throughout July 2019.

• The ambient PM$_{2.5}$ data was downloaded from the SD memory cards weekly, zipped and passworded and sent via email to the PI who then cleaned and analysed the data.

• A log of challenges encountered was kept by all exposure scientists, zipped and sent to the Principal Investigator weekly alongside the site datasets.

• Coordination and remote support provided via a WhatsApp® platform.
Methodology- PurpleAir Installation Site Agreements

• Purple Air-II-SD device and one 20,000 mAh long-lasting portable Anker® power bank (Anker Innovations, Changsha, China).

• Standard operating procedures for installing and mounting the Purple Air-II-SD device at each site: Device is
  • (i) Sited away from obstructions e.g. walls, big trees etc;
  • (ii) A good distance away from a road with heavy traffic i.e., minimum 100 m;
  • (iii) Placed at two meters from the ground level for uniformity and ease of data comparability;
  • (iv) Sited away from non-traffic particulate matter sources such as grills, generators, incinerators, AC vents etc.

• NB: Post installation pictures were taken and sent to the group.
Purple Air-II-SD: ubiquitous tool. Undergone validation

- Independent evaluation data shows very good agreement ($R^2 > 0.95$) with gold standard instruments

$y = 0.6241x + 2.7288$
$R^2 = 0.9791$

PM$_{2.5}$ (5-min mean; $\mu g/m^3$)

Unit 8464

http://www.aqmd.gov/aq-spec/evaluations/field
Does the Purple Air accurately measure high concentrations of smoke?

SP vs Purple Air

Sidepak PM2.5 (ug/m³) vs Purple Air PNC 2.5μm/dl

y = 0.5436x
R² = 0.9833
## Results - Data recovery from the sensors at the MA3 sites

<table>
<thead>
<tr>
<th>Country</th>
<th>Town &amp; City</th>
<th>Number of Records logged (n)</th>
<th>PA° time periods (N)</th>
<th>Data recovery rates (%)</th>
<th>Daily period average (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Gambia</td>
<td>Fajara, Kombo</td>
<td>20,636</td>
<td>22,320</td>
<td>94.7%</td>
<td>15.6</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>Balkuy, Ouagadougou</td>
<td>21,142</td>
<td>22,320</td>
<td>94.7%</td>
<td>19.4</td>
</tr>
<tr>
<td>Benin Republic</td>
<td>Akpakpa, Cotonou</td>
<td>30,799</td>
<td>33,480</td>
<td>92.0%</td>
<td>22.1</td>
</tr>
<tr>
<td>Nigeria</td>
<td>Abakaliki Rd, Enugu</td>
<td>32,999</td>
<td>33,480</td>
<td>98.6%</td>
<td>28.8</td>
</tr>
<tr>
<td>Nigeria</td>
<td>Trans-Ekulu, Enugu</td>
<td>31,139</td>
<td>33,480</td>
<td>93.0%</td>
<td>30.3</td>
</tr>
<tr>
<td>Nigeria</td>
<td>Goshen, Enugu</td>
<td>35,322</td>
<td>33,480</td>
<td>105.5%</td>
<td>22.1</td>
</tr>
<tr>
<td>Nigeria</td>
<td>New Haven, Enugu</td>
<td>31,241</td>
<td>33,480</td>
<td>93.3%</td>
<td>30.3</td>
</tr>
<tr>
<td>Nigeria</td>
<td>Awka, Anambra</td>
<td>31,500</td>
<td>33,480</td>
<td>94.1%</td>
<td>33.0</td>
</tr>
<tr>
<td>Kenya</td>
<td>Ngong Rd., Nairobi</td>
<td>22,320</td>
<td>22,320</td>
<td>100.0%</td>
<td>38.8</td>
</tr>
<tr>
<td>Nigeria</td>
<td>Nnewi, Anambra</td>
<td>21,078</td>
<td>22,320</td>
<td>94.4%</td>
<td>52.3</td>
</tr>
<tr>
<td>Uganda</td>
<td>Ntinda, Kampala</td>
<td>21,312</td>
<td>22,320</td>
<td>95.5%</td>
<td>91.1</td>
</tr>
<tr>
<td>Nigeria</td>
<td>Bariga, Lagos</td>
<td>24,148#</td>
<td>33,480</td>
<td>72.1%</td>
<td>56.3</td>
</tr>
</tbody>
</table>
Results - Data recovery from the sensors at the MA3 sites

- Data recovery ranged from 72.1% (Bariga-Lagos-Nigeria) to 100% (Nairobi, Kenya);
- The overall median recovery rate was 94%.
- All sites recorded daily PM$_{2.5}$ averages higher than 15 μg/m$^3$ (WHO recommended threshold);
Results - Practical Challenges encountered

- Practical challenges experienced in the process of use of the Purple Air-II-SD sensors were
  - Power and power pack outages,
  - Device set-up issues
  - SD memory card issues,
  - Internet connectivity problems and
  - Sensor hardware maintenance concerns.

  NB: Only two sites could sustain wi-fi access for one month

<table>
<thead>
<tr>
<th>Issues</th>
<th>Specific Characteristics</th>
<th>Reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Issues</td>
<td>No power problems reported</td>
<td>5 (41.7%)</td>
</tr>
<tr>
<td></td>
<td>Irregular electricity supply</td>
<td>4 (33.3%)</td>
</tr>
<tr>
<td></td>
<td>Additional Power bank needed</td>
<td>1 (8.3%)</td>
</tr>
<tr>
<td></td>
<td>Use of electricity generators</td>
<td>2 (16.7%)</td>
</tr>
<tr>
<td>Device Set-up</td>
<td>No set-up issues reported</td>
<td>6 (50%)</td>
</tr>
<tr>
<td></td>
<td>Finding suitable location for device set-up</td>
<td>2 (16.7%)</td>
</tr>
<tr>
<td></td>
<td>Incurring extra cost for assisted device set-up</td>
<td>2 (16.7%)</td>
</tr>
<tr>
<td></td>
<td>Keeping device safe from theft, children, etc.</td>
<td>1 (8.3%)</td>
</tr>
<tr>
<td></td>
<td>Connecting to Wifi</td>
<td>1 (8.3%)</td>
</tr>
<tr>
<td>Memory Card</td>
<td>No SD memory card problems</td>
<td>10 (83.3%)</td>
</tr>
<tr>
<td></td>
<td>Problems with removal and re-insertion of SD card</td>
<td>2 (16.7%)</td>
</tr>
<tr>
<td>Data download</td>
<td>No data downloaded problems</td>
<td>8 (66.7%)</td>
</tr>
<tr>
<td></td>
<td>Extracting data from wifi</td>
<td>1 (8.3%)</td>
</tr>
<tr>
<td></td>
<td>Card reader issues</td>
<td>3 (25%)</td>
</tr>
</tbody>
</table>
Conclusions

• Main challenges identified were power, device set-up issues, internet connectivity & SD memory card problems.

• These challenges were overcome through creative solutions;

• PM$_{2.5}$ longitudinal measurement can be reasonably satisfactorily executed in sub-Saharan African countries using the Purple Air-II-SD device.
Acknowledgements

Prof. Kevin Mortimer
Dr. Gabriel Okello

Lancaster University

Dr. Chris Jewell
Dr. Olatunji Johnson

UNIVERSITY OF CAMBRIDGE

Ass. Prof Sean Semple
Dr. Ruairidh Dobson

LSTM

Prof. Graham Devereux

University of Stirling

Dr. Annette Erhart

African Centre for Clean Air

MA3 Consortium & Associates

Endurance Awokola

Air Sensors Int. Conf.

CAMS-Net
Air sensing to action in the African context: design and deployment of a community-driven digital air quality sensing network for African cities. - Engineer Bainomugisha, AirQo/Makerere University
Session Q&A Discussion

Please submit your questions for the session speakers through Whova – on your mobile or desktop device.

Make sure to note WHOM your question should be addressed to.
Thank you for joining Part 1 of the session!

Part 2 will begin momentarily.

Session 5A Part 2 Speakers:

Dan Westervelt, CAMS-Net
Michael Johnson, Berkeley Air
Priyanka deSouza, University of Colorado Denver
Michael R Giordano, AfriqAir