Performance Evaluation of Portable Air Monitoring Platforms (PAMPs) for Community-Based Air Monitoring and Citizen Science

Zheng Yang, Shane A Taylor, Cristen Adams, Greg Wentworth, Charlene Puttick, and Bob Myrick Environmental Monitoring and Science Division, Alberta Environment and Parks

Introduction

As a province with frequent forest fires and industrial releases, air quality has always been a hot topic of concern. Many citizens hope to have more extensive community-based air monitoring systems. Some citizens prefer to use affordable and reliable monitors to measure the air quality more locally.

Portable air monitoring platforms (PAMPs) offer an exciting opportunity for people to use this technology for a wide range of applications beyond traditional regulatory monitoring, because they are smaller, easier to deploy, use less power and cost less than conventional air monitoring stations. As such, they are identified in the draft **Alberta 5-Year Air Quality and Deposition Monitoring Plan** as an alternative monitoring technology.

Various PAMP systems have become commercially available as the market is expanding rapidly. Based on the technology available now, the PAMPs mainly contain two types of systems: compact air monitoring systems, and miniature sensor-based integrated air quality systems.

Compact Air Monitoring Systems

- House conventional air quality analyzers in compact and portable systems, or
- Use smaller air quality analyzer modules that have the same working principle as conventional air quality analyzers

Example: Airpointer 2D, 4D, and +PM

- Capable of analyzing O_3, CO, SO_2, H_2S, NO/NO_2/NO_x, $PM_{2.5}$, etc.
- Use Federal Equivalent Methods (FEM) for measurement
- Modular design for removal and exchange of analyzers
- Enclosure is temperature controlled (-30°C to +40°C)
- External calibration port and automated zero for all gases
- Remote access for regular maintenance and downloading data
- Compatible with Alberta air monitoring data management system

Compared with conventional air monitoring stations, it has the following advantages: less initial investment, lower maintenance costs (instruments and personnel), less energy consumption, smaller footprint, and easier deployment.

Miniature Sensor-Based Integrated Air Quality Systems

- Use next generation air monitoring sensors to provide air quality data
- Sensors work based on various principles, including electrochemical, metal oxide semiconductor, infrared, etc. (not FEM)

Example: Aeroqual AQY 1

Example: Vaisala AQT 420

- Real-time continuous measurement of the key urban pollutants: $PM_{2.5}$ & PM_{10}, NO_2 and O_3 (SO_2, CO, etc. also available), and weather data, such as humidity, air pressure and temperature
- Effects of interference, temperature, humidity and aging on sensors are compensated by advanced adaptive algorithms
- Sensing device is packed with advanced technology that delivers scientifically credible data in a wide variety of environmental conditions
- Power consumption is very low and systems can be solar/battery powered
- Sensors are low-cost compared to traditional air quality analyzers
- Flexible communication platform makes real-time data available wirelessly and locally, and gives secure access through an Application Programming Interface
- Web interface can be accessed via browser on your phone, tablet or PC, where you can see all your data in one place and set alerts on parameters of concern
- Very small size, quick and easy to set up, and relocate under 5 minutes

Specification Comparison

NO_2	Principle	Range	Detection Limit
Airpointer ($NO/NO_2/NO_x$)	chemiluminescence	up to 20 ppm	0.4 ppb
Aeroqual-AQY 1	electrochemical	0-0.5 ppm	2 ppb
Vaisala-AQT 420	electrochemical	0-2 ppm	5 ppb

O_3	Principle	Range	Detection Limit
Airpointer	UV absorption	up to 20 ppm	0.5 ppb
Aeroqual-AQY 1	semiconductor	0-0.2 ppm	1 ppb
Vaisala-AQT 420	electrochemical	0-2 ppm	5 ppb

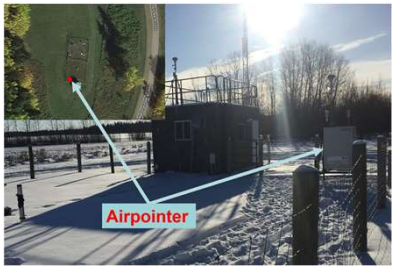
PM	Principle	Range	Detection Limit
Airpointer (+PM)	nephelometer and beta attenuation	0-1000 µg/m³ and higher	< 0.5 µg/m³
Aeroqual-AQY 1	optical particle counter	0-1000 µg/m³	<1 µg/m³
Vaisala-AQT 420	optical particle counter	0-2000 µg/m³	<1 µg/m³

	Operating T Range	Dimension	Power Consumption
Airpointer (+PM)	-30°C to +40°C	1.2 x 0.78 x 0.62 m	< 1100 W
Aeroqual-AQY 1	-20°C to +40°C	0.215 x 0.17 x 0.125 m	< 24 W
Vaisala-AQT 420	-30°C to +40°C	0.185 × 0.128 × 0.128 m	< 5 W

Co-Location Comparison Study

EMSD deployed an Airpointer to the Elk Island long-term air monitoring station (AMS) in November 2017 and will conduct co-location performance test until early 2019.

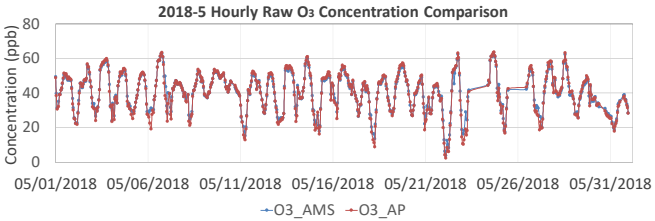
- Collect and analyze both raw and corrected data from the Airpointer and co-located Elk Island AMS
- Check the status of the Airpointer on a regular basis, identify and resolve issues
- Calibrate the Airpointer under various conditions and evaluate the performance after each calibration



- Draft a SOP outlining the procedures of installation, operation, and calibration
- Identify other suitable and commercially available PAMPs for evaluation

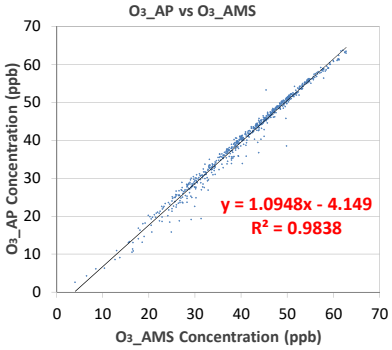
Data Comparison Methods

Time Series Plot



Scatterplot and Linear Regression

R^2 is a statistical term in linear regression. It represents how well an analyzer performs in comparison to the reference monitoring technologies. A value of R^2=1 would mean the sensor has perfect correlation to the reference monitor, and R^2=0 would mean no correlation to a reference monitor.



Project Deliverables

Advantages and features will be identified for tested systems for applications in various projects, including expansion of air monitoring networks, community-based air monitoring, and citizen science initiatives, etc. It will also recommend methodologies, guidelines and tools for enhancing credibility of data and results from PAMPs.