Taiwan’s Air Quality Monitoring

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Outline

1. Air Quality Monitoring Network
2. Monitoring Data Sharing
3. Air Quality Sensor
4. TAIWAN projects
5. For the Future
Multi-Class Air Quality Monitoring Network

- National Station Network
  - EPB: 26 stations
  - Industrial area: 26 stations
  - State-owned business: 72 stations
  - Total: 77 stations

- Regional Station Network
- Smart Cities and Towns
- Internet of Things
  - 10,200 Sensors in 2020 years

- Civilian Mobile Sensors / Smart Community Air Quality Sites
  - Many Low
  - Few High
  - Cost Data Quality
  - Data Quantity

Map showing distribution of stations across Taiwan.
Types of Air Quality Monitoring Station

Since 1994, our monitoring data update online at TAQMN on a hourly basis:
- Ambient air quality stations: 60
- Industrial monitoring stations: 5
- Traffic monitoring stations: 12
- National park monitoring stations: 2
- Air quality background stations: 4

Particulate matter composition stations

The photo chemical stations

The mobile stations
### Monitoring Items

<table>
<thead>
<tr>
<th>Criteria Pollutants</th>
<th>Meteorological Parameters</th>
<th>Others</th>
</tr>
</thead>
</table>
| • PM$_{10}$, PM$_{2.5}$  
• CO  
• SO$_2$  
• NO$_2$  
• O$_3$, O$_{3\text{-8hr}}$ | • Wind Speed  
• Wind Direction  
• Temperature  
• Humidity  
• Rainfall | • Acid rain  
• THC Total hydrocarbons  
• CH$_4$ methane  
• NMHC  
• UVB  
• UVA  
• BTEX  
• CO$_2$ |

### Manual

- PM$_{2.5}$  
- PM$_{2.5}$ Chemical composition analysis
Photochemical Assessment Monitoring Stations

- Photochemical Assessment Monitoring Stations (PAMS): 11
- Monitoring items: 54 types of O₃ precursors

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Chemical Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethane</td>
<td>2,3-Dimethylpentane</td>
</tr>
<tr>
<td>Ethylene</td>
<td>3-Methylhexane</td>
</tr>
<tr>
<td>Propane</td>
<td>2,2,4-Trimethylpentane</td>
</tr>
<tr>
<td>Propylene</td>
<td>n-Heptane</td>
</tr>
<tr>
<td>Isobutane</td>
<td>Methylcyclohexane</td>
</tr>
<tr>
<td>n-Butane</td>
<td>2,3,4-Trimethylpentane</td>
</tr>
<tr>
<td>Acetylene</td>
<td>Toluene</td>
</tr>
<tr>
<td>t-2-butene</td>
<td>2-Methylheptane</td>
</tr>
<tr>
<td>1-Butene</td>
<td>3-Methylheptane</td>
</tr>
<tr>
<td>cis-2-Butene</td>
<td>n-Octane</td>
</tr>
<tr>
<td>Cyclopentane</td>
<td>Ethylbenzene</td>
</tr>
<tr>
<td>Isopentane</td>
<td>m,p-Xylene</td>
</tr>
<tr>
<td>n-pentane</td>
<td>Styrene</td>
</tr>
<tr>
<td>t-2-pentene</td>
<td>o-Xylene</td>
</tr>
<tr>
<td>1-pentene</td>
<td>n-Nonane</td>
</tr>
<tr>
<td>c-2-pentene</td>
<td>Isopropylbenzene</td>
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<tr>
<td>2,2-dimethylbutane</td>
<td>n-Propylbenzene</td>
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<tr>
<td>2,3-dimethylbutane</td>
<td>m-Ethyltoluene</td>
</tr>
<tr>
<td>2-methylpentane</td>
<td>p-Ethyltoluene</td>
</tr>
<tr>
<td>3-methylpentane</td>
<td>1,3,5-Trimethylbenzene</td>
</tr>
<tr>
<td>Isoprene</td>
<td>o-Ethyltoluene</td>
</tr>
<tr>
<td>n-Hexane</td>
<td>1,2,4-Trimethylbenzene</td>
</tr>
<tr>
<td>Methylcyclopentane</td>
<td>n-Decane</td>
</tr>
<tr>
<td>2,4-Dimethylpentane</td>
<td>1,2,3-Trimethylbenzene</td>
</tr>
<tr>
<td>Benzene</td>
<td>m-Diethylbenzene</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>p-Diethylbenzene</td>
</tr>
<tr>
<td>2-Methylhexane</td>
<td>n-Undecane</td>
</tr>
</tbody>
</table>
Scheduled quality control procedures
- Daily zero and span checks
- Biweekly precision checks
- Quarterly multiple-point calibrations

Calibration standards
- CO, SO$_2$, and NO are traceable to the US NIST standards within ±2%
- Ozone transfer standard is traceable to US NIST Standard Reference Photometer #30 and #57

Quality assurance
- Performance audit
- Functional checks
- Data validations
Long-term Trends of Air Quality

The country map displays the current AQI’s colorful icon which is updated hourly.

Users can select a region to view detailed data.

<table>
<thead>
<tr>
<th>Location</th>
<th>AQI</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puli</td>
<td>44</td>
<td>Good</td>
</tr>
</tbody>
</table>

- **O₃ (ppb)**
  - 8-hour Moving Average: 48
  - Hourly Concentration: 36

- **PM₂.₅ (µg/m³)**
  - Moving Average: 10
  - Hourly Concentration: 13

- **PM₁₀ (µg/m³)**
  - Moving Average: 13
  - Hourly Concentration: 19

- **CO (ppm)**
  - 8-hour Moving Average: 0.20
  - Hourly Concentration: 0.26

- **SO₂ (ppb)**
  - Hourly Concentration: 0.8

- **NO₂ (ppb)**
  - Hourly Concentration: 7.6

AQL value and impact on health

http://taqm.epa.gov.tw
Air Quality Forecast

- 3-days-forecast
- Forecast video
Since 2009, the primary pollutants decrease except for O₃, the challenge is to conduct lower concentration monitoring and to find ways to decrease the concentration of O₃.
Briefing the Lulin station

23.51°N, 120.92°E ; 2862 m
On top of Mt.Lulin to track the trans-boundary transport of atmospheric pollutants
Monitoring Data

Transmit

Database Server

Primary analysis

• TAQMN (Taiwan Air Quality Monitoring Network)
  • Minute data (Gas items)
  • Hourly data
  • Historical data

• Environmental Instant Messages APP

• Data Open Platform
GPS Information

- Past, now and future information on air quality
- Instant warnings such as air quality, heavy rain, flooding and earthquakes according to the user's location

Post

Users upload the air quality photos and moods of their locations

Immediately show user neighborhood real-time environment information
Slide Finger, Get Information So Easy

Air Quality Index (AQI)

Hourly Data

Activity Guidance

AQI Forecast (12hrs)

Update AQI forecast data twice per hour
Downloads
500,000

2013
Officially online

2015.6
Version 2.0

2016.10
Connect Bluetooth of Sensors

2016.12
Air Quality Index (AQI)

2017.2
English version

2017.3
New interface
Air quality mood upload

2018.2
AQI Forecast

Award

2016
Geospatial Application
Geospatial World Excellence Award

2016
Internet of Things Innovation Award

2017
Digital Government Innovative Products Award
1. Instant Information

AQI, Air quality forecast, Weather, UV index, River Pollution Index...

2. Trend

3 days historical data trend of every monitoring stations

3. Map Guide

AQI, PM$_{2.5}$, PM$_{10}$, O$_3$, SO$_2$... in different spatial scales by map

4. Overview

Sorting AQI, PM$_{2.5}$, PM$_{10}$, O$_3$, SO$_2$... by values in national stations

5. Personalized warning

The warning value can be set according to personal preference

6. Upgrade

Short description of every air quality and 3-days-forecast

7. Mood Post

Users upload the air quality photos and moods

讓大家都看得到！
Provides a platform for automatically tracking data lineage while monitoring workflow execution, supports tasks to systematically collect diverse monitoring data.

Taiwan’s OpenData - Air Quality Monitoring Data
(http://opendata.epa.gov.tw/)
Total sensing solution of air quality sensor

- **Capable of measuring temperature, humidity, O₃, CO, PM₂.₅, noise, and TVOC**

- **Components**:
  1. Main chassis: Equipped with a power supply module, backup battery, control board, radio transmitter module, memory card, and terminal panel.
  2. Radiation shield: Equipped with a sensor board and various types of sensor components.
  3. Mount: A U-shaped ring or stainless steel tube bundle is used to secure the sensor to the utility pole.
  4. Power requirements: 110/220V AC, 1A.
Deployment of pilot fields (3,300 fields in total)

- Provision of one sensing data, including temperature, humidity, and PM$_{2.5}$, every three minutes
- Coverage of 120 regional administrative areas, 44 industrial zones, and science parks
- Monitoring 3,800 designated factories

Data integration and AI analysis

- Inclusion of PRTR, CEMS, complaints of public nuisances, wind fields, and other related data, supplementing real-time analysis of potential pollutions and real-time alarming information
- Pinpointing polluting hot spots and times with big data
- Discovery of 47 enterprises in violation of environmental-protection laws/regulations
Application scenarios for smart law enforcement

**Long-term auditing**

- IoT sensor data can narrow suspicious area
- Continuing data monitoring grasp of abnormal behaviors of factories
- In combination with on-site auditing with scientific tools

**Pinpointing suspicious factories intensively with sensor data**

**On-site inspection with the assistance of scientific tools**

- Intensive on-site inspection
- On-site sampling
- Thermal imager
- VOC imager
Fully automated computing of AI system assists environmental auditing units in grasping short-term unexpected incidents, as well as dissemination time and scope.
TAiWAN projects

- Taiwan, as an IoT site, provides guidance on innovation and R&D
- Deploying a wide air quality network to control pollution and protect the environment
- Duplicating and exporting our services and experiences in software and hardware
- Improving our products and services for a sustainable future

77 national-level standard sensing stations
10,000 smart urban & rural sensing points
10,000+ citizens' scientific sensing points
Smart City—Internet of Everything
For the Future

• Review TAQMN to meet the requirements of new air quality problems

• Provide more information about long-range and transboundary transport

• Look forward to further international cooperation in the future
Many thanks for your attention!