Operational experience of the particulate matter monitoring system in Miskolc

Csongor Báthory
Project manager, University of Miskolc
Particulate Matter

Health limit:

- $\text{PM}_{10}$: 50 $\mu$g/m$^3$ (daily average)
- $\text{PM}_{2.5}$: 25 $\mu$g/m$^3$ (yearly average)

Operational experience of the particulate matter monitoring system in Miskolc
PM issues in Miskolc

PM$_{10}$ daily average in 2020 Miskolc, official monitoring station

Source: Országos Légszennyezettségi Mérőhálózat (levegominoseg.hu)

Population: 160,000
Area: 236.7 km$^2$
Inversion in Miskolc

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International examples

USA

https://purpleair.com

Europe

https://airly.eu

https://sensor.community

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Sensor selection

- Sensor with fan
- Measured PM$_{2.5}$ and PM$_{10}$ concentrations [$\mu g/m^3$]
- Best correlation compared to a reference method
- Low humidity dependence
- Growing scientific interest:
  - 2018: 8 articles
  - 2019: 8 articles
  - 2020: 20 articles
  - 2021: 26 articles

Plantower PMS7003
Measurement device

3D printed lamellar protective housing

Raspberry Pi 3 B

Environmental sensor

SIM modul

PM sensor

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Calibration in climate chamber

Reference: TSI DustTrack 8534-M (TSI) (light scattering)
Accuracy: ±1 µg/m³ or ±1%
First operational experience of a high-resolution particulate matter monitoring system in Miskolc

On-field measurement

<table>
<thead>
<tr>
<th>Unit</th>
<th>Data Log</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRIMM EDM 180</td>
<td>1 min</td>
</tr>
<tr>
<td>LIFE 001</td>
<td>5 sec</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Start</th>
<th>Stop</th>
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</thead>
<tbody>
<tr>
<td>2019.07.06.</td>
<td>2020.09.30</td>
</tr>
</tbody>
</table>
Calculation model

Raw data

Climate chamber calibration

Humidity compensation

Average absolute error rate decrease

40% — — — — — — — — — — 25%
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# Authentic/Non-authentic data

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Official</th>
<th>HungAIRy</th>
<th>Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device with type approval</td>
<td>✔️</td>
<td>✖️</td>
<td>✖️</td>
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<tr>
<td>Accredited laboratory</td>
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<tr>
<td>Calibration</td>
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<tr>
<td>Validation</td>
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<tr>
<td>Scheduled maintenance</td>
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<tr>
<td>Service</td>
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<tr>
<td>Urban scale</td>
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<td>✔️</td>
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</tbody>
</table>

Operational experience of the particulate matter monitoring system in Miskolc
Urban scale laboratory

Monitoring system

Urban air quality

Installation requirements

Sensors reliability

System accuracy

Map display

Distribution of pollutants

Impact of topography

Detection of hotspots

Smog formation process

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Valley effect

T=7 °C  RH=92.8%
Valley effect

Operational experience of the particulate matter monitoring system in Miskolc
Valley effect

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Evening PM Development

Sunday

T=10.3 °C  RH=76.6%

T=7.5 °C  RH=84.7%

T=8.8 °C  RH=80%

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Morning PM Development

Monday

Operational experience of the particulate matter monitoring system in Miskolc
Effect of humidity and fog

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Achieved goals

- **Low-cost device**
  - Under 300 EUR
- **Science based development**
  - Measurement and targeted testing
- **Getting to know errors**
  - Humidity dependence
- **Troubleshooting**
  - Calibration, Artificial Neural Network
- **Tracking trends**
  - Temporal and spatial specific

Information Communication

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pmmonitoring.hu
Future Plans

Baseline

Monitoring

Involvement of educational institutions

Expension to nearby settlements

2022

2023

2024

2025

2026

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Mobile sensing

- Microcontroller (Raspberry Pi Zero)
- GPS module (NEO-6M)
- T, RH, P sensor (BME 280)
- PM sensor (Plantower 7003)
- RTC chip (DS3231)

Hotspot identification with portable low-cost particulate matter sensor (International Journal of EWFN)

The Research Interest Score (4.0) at ResearchGate is higher than 93% of items published in 2019.
Mobile sensoring

PM$_{2.5}$ [$\mu$g/m$^3$]

Sarasota - Bentley’s Boutique Hotel

Miskolc - Fehérkőlápa

Sarasota - Sierra Beach

Miskolc – Martin-kertváros
Mobile sensing

DJI S800
Multicopter with 6 rotor 360W

**UAV**

- Customized Matrice 600Pro hexacopter (stripped of all non-essential part to save weight);
- Equipped with prototype environmental head developed by Optimum Tymiński i sk-a in cooperation with Dept. of Clim. and Env. Prot. UW;
- Measurement of PM$_{10}$, PM$_{2.5}$, $O_3$ concentration, air temperature and humidity, registration of flight parameters;
- Flight up to 40 min; distance 2 km;
- Purchased thanks to a grant from the Municipal Office of Wroclaw

Anetta Drzeniecka-Osiadacz, Tymoteusz Sawiński, Magdalena Korzystka-Muskala, Marek Kowalczyk, Piotr Modzei, “Do you know what you breathe?” — educational and information campaign for cleaner air, University of Wroclaw
Acknowledgments

With the contribution of the LIFE Programme of the European Commission LIFE17 IPE/HU/000017