EVALUATING PROCESS OF LOW-COST DEVICES AND THEIR EFFICIENCY FOR AIR QUALITY MONITORING

Sonja Dmitrašinović[1], Jelena Radonić[1]

[1] Department of Environmental Engineering and Occupational Safety and Health,
Faculty of Technical Sciences,
University of Novi Sad

Data calibration of four low-cost sensors (LCS) by performing collocation of LCS with reference monitoring station (RFS).

LCS performance evaluation was conducted in order to examine accuracy, error, and precision of measuring $PM_{2.5}$ in ambient conditions and examine efficiency of the calibration process.

- Collocation process implied RFS and LCS to operate at the same time and place under real-world conditions for certain evaluation period, to calibrate 1h and 24h data.
- Each sensor was placed next to the other in the vicinity of RFS at a distance of 2.5 m and height of 1.2 m, for 14 days (Pict. 1-2).

Picture 1 and 2.

Results

- A review of collected data after the evaluation period, showed a few outliers present in all four LCS data sets, more extreme in case of 1h frequency measurement, but also sudden changes in a sensor's response over the evaluation period in the form of higher or lower $PM_{2.5}$ concentrations comparing to RFS data.
- 1h frequency measurement (Table 1):
- Determination coefficient (R2) values were in range 0.79 – 0.82 (e.g. LCS1, Figure 3).
- Mean absolute error (MAE) and relative error (RE) values were in the range 2.33 - 2.70 µg/m³ and 25.9 – 40%.
- Mean and standard deviation (SD) values of RFS data were 7.90 and 3.84 µg/m³ and for LCS1-4 were in range 6.39-8.84 and 5.21 – 6.35 µg/m³.
- 24h frequency measurement (Table 1):
- R2 (e.g. LCS1, Figure 4), MAE and RE values were in range 0.84-0.85, 1.38-1.85 µg/m³ and 17-25%.
- Mean and SD values from RFS were 8.05 and 2.3 µg/m³, and for LCS1-4 were in range 6.59-8.98 and 3.35-4.33 µg/m³.

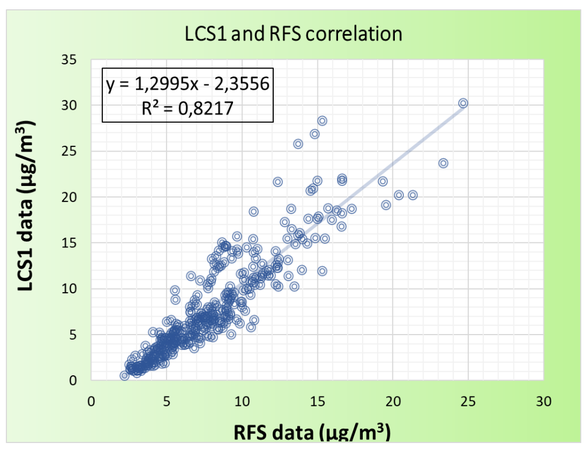

Figure 3.

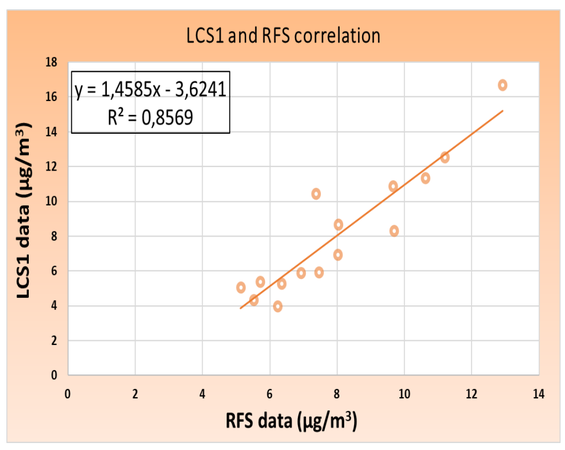

Figure 4.

Device and frequency	Mean (µg/m³)	SD	MAE	RE (%)
RFS 1h	7.9	3.8	-	-
LCS1	7.9	5.5	1.8	25.9
LCS2	8.8	6.3	2.2	27.9
LCS3	6.4	5.2	2.5	39.0
LCS4	6.9	5.7	2.4	40.0
RFS 24h	8.1	2.3	-	-
LCS1	8.1	3.6	1.4	17.0
LCS2	9.0	4.3	1.7	18.5
LCS3	6.6	3.4	1.9	25.8
LCS4	7.2	3.7	1.8	24.3

- R2 indicates a strong correlation of LCS data with RFS data.
- LCS provide good insights into $PM_{2.5}$ pollution trends in the form of a decrease or increase of $PM_{2.5}$ concentrations (e.g. LCS1, Fig. 5 and 7) .
- The precision of the LCS is relatively low, since SD values of LCS data showed high dispersion of a data set relative to its mean.
- The measurement accuracy for both LCS data frequencies was moderate, comparing to RFS measurement.
- Slope and intercept values are further used for LCS 1h and 24h data calibration by applying inverse linear regression to increase the accuracy of the LCS data.

Calibration efficiency:

- MAE and RE values for 1h data were in the range 1.2 – 1.3 µg/m³ and 16-20% (Fig.6)
- MAE and RE values for 24h data were in the range 0.7-0.77 µg/m³ and 9-10% (Fig.8)

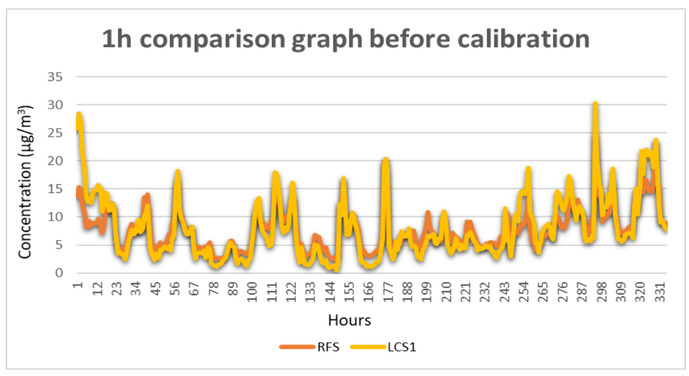

Figure 5.

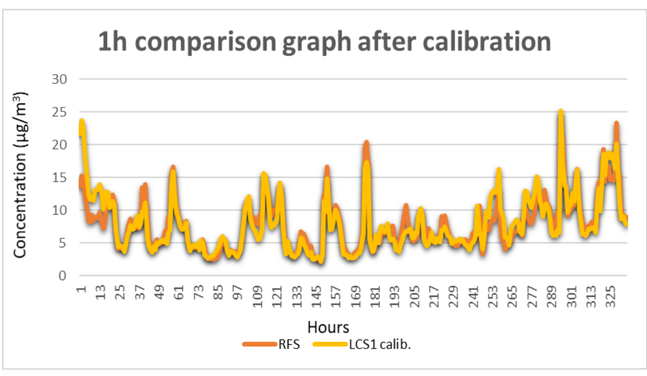

Figure 6.

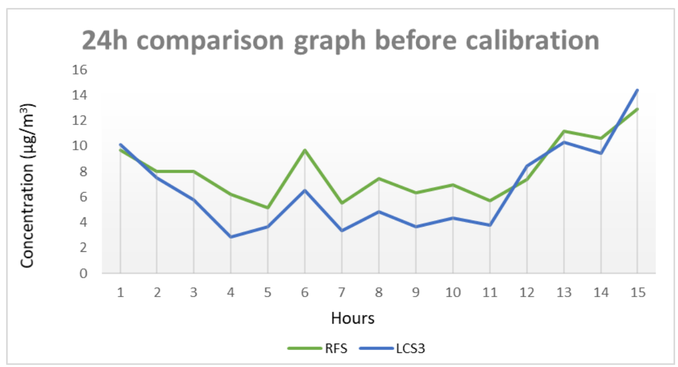

Figure 7.

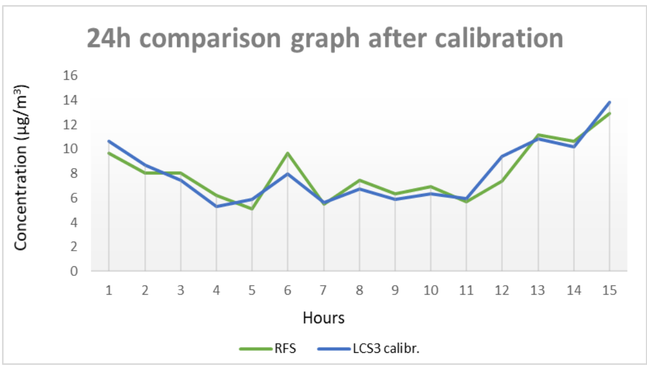

Figure 8.

- The efficiency of applying LCS in $PM_{2.5}$ pollution monitoring is modest.
- Basic data analysis results confirm that periodic calibration of LC devices and data is critical in reducing the error of sensor measurements and in characterizing and mitigating long-term sensor performance issues.

Acknowledgment

This research (paper) has been supported by the Ministry of Education, Science and Technological Development through the project no. 451-03-68/2020-14/200156: "Innovative scientific and artistic research from the FTS (activity) domain".

WWW.DEMOCRATIA-AQUA.ORG

Funded by the DAAD from funds of the Federal Foreign Office:
DAAD Deutscher Akademischer Austauschdienst German Academic Exchange Service
Federal Foreign Office