European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

WGs and MC Meeting at ISTANBUL, 3-5 December 2014

Action Start date: 01/07/2012 - Action End date: 30/06/2016

Year 3: 1 July 2014 - 30 June 2015 (*Ongoing Action*)

AN EXAMPLE OF LOW-COST DEVICE FOR INDICATIVE INDOOR PM, CO2 AND METEOROLOGICAL PARAMETERS MONITORING

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DESCRIPTION OF THE UNIT(S) USED IN CITI-SENSE IAQ IN SCHOOLS PILOT STUDY

- Integration of all parts, electronic design, data transmission and data visualization has been done by Dunavnet (Serbia)-DNET static unit
- Low cost sensors for selected meteorological parameters (t, RH, p) and gases (NO, NO_2, CO, CO_2, O_3) has been produced by Alphasense (UK)
- Particulate matter monitor ($PM_{0.5-2.5}$ and $PM_{2.5-10}$ μm) has been produced by DYLOS (USA)

CITI-SENSE project Grant agreement nº: 308524

DESCRIPTION OF THE UNIT(S) USED IN CITI-SENSE IAQ IN SCHOOLS PILOT STUDY

- Calibration in the field, was done by Institute Vinča (Serbia) in cooperation with Serbian Environmental Protection Agency (SEPA)

- Activities of device validation and data presentation and analysing, performed in cooperation of Institute Vinča (Serbia), DunavNET (Serbia), QUT (Australia)

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THE MAIN GOALS OF VALIDATION LOW-COST UNIT WITH GAS AND PM SENSORS IN THE FIELD

- To adjust for inter-sensor node differences in sensitivity that need to be applied across the range of these concentrations and other conditions without significant bias being introduced
- To validate consistency after repeated use in conditions with low and high levels of pollutants and meteorological data
- To compare the sensitivity with reference devices and other widely used commercial instruments

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UNIT CALIBRATION WITH REFERENCE INSTRUMENTS

- Calibration of the DYLOS 1700 monitor for PM10 and PM2.5, was based on co-locating it with a reference instrument, the GRIM monitor, at an automatic monitor station that is part of the network run by the Serbian Environmental Protection Agency (SEPA).
- The data were recorded with same frequency for the DYLOS 1700 platforms and for the reference instruments. Therefore prior to preforming the calibration procedure it was necessary to perform time adjustment, interpolation, the DYLOS data and GRIM monitor data.

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UNIT CALIBRATION WITH REFERENCE INSTRUMENTS

- We have first performed a filtering of the signals from the platforms by using a smooth function precisely described by Gracia* that provide examples of simplified Matlab codes. This allows fast, automatic and robust smoothing of signals with arbitrary dimensions followed by conversion of the count to mass concentration on the basis of aproximative, literature data. Smooth function provides an option to set the input parameter of smoothness which it is possible to control the filtering process. By increasing the smoothness, the correlation coefficient between the signals from the low-cost sensors and reference monitors has improved.

*D.Gracia, Computational Statistics and Data Analysis, 54(2010)1167-1178

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Conversion count to mass concentration, an conservative approach

Conversion to mass concentration was perform under strong assumption:

- All particles are spherical, with a density of 1.65E12 µg/m^3 [*,**]
- The radius of a particle in the channel <2.5 µm is 0.44 µm [**,***]
- The radius of a particle in the channel > 2.5 is 2.60 µm [**,***]

*A. Tittarelli, A. Borgini, M. Bertoldi, E. De Saeger, A. Ruprecht, R. Stefanoni, G. Tagliabue, P. Contiero, P. Crosignani "Estimation of particle mass concentration in ambient air using a particle counter," *Atmospheric Environment*, **42** (2008) 8543-8548

**M. Uva, R. Falcone, A. McClellan, E. Ostapowicz, Preliminary Screening System for Ambient Air Quality in Southeast Philadelphia -Data Validation, , Electrical and Computer Engineering Department of Drexel University May 13, 2009 May 13, 2009 (accessed October 2014)

***Lee, J. et al., "Seasonal variations of particle size distributions of PAHs at Seoul, South Korea", *Air Quality Atmospheric Health*, **1** (2008) 57-68

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UNIT CALIBRATION WITH REFERENCE INSTRUMENTS

Dnet static units for were collocated at AMS Novi Beograd March 17th-April 10th

.

platform no	CO_2 Ref/pl	$PM_{2.5}$ Ref/pl	PM_{10} Ref/pl	T Ref/pl	H Ref/pl	p Ref/pl
7	-0,857	0,824	0.924	0,957	0,971	0,997
9	-0,838	0,824	0.802	0,971	0,980	0,997
13	-0,819	0,853	0.765	0,960	0,973	0,997

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PILOT SCHOOL IN BELGRADE:ELEMETARY SCHOOL “20. OKTOBAR”, NEW BELGRADE

- We started with monitoring indoor and outdoor school environment with Dnet unit in spring 2014

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SCHOOL ENVIRONMENT
INDOOR AIR QUALITY

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SCHOOL ENVIRONMENT
OUTDOOR AIR QUALITY

Teachers room

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SCHOOL ENVIRONMENT
INDOOR AIR QUALITY

Teachers room

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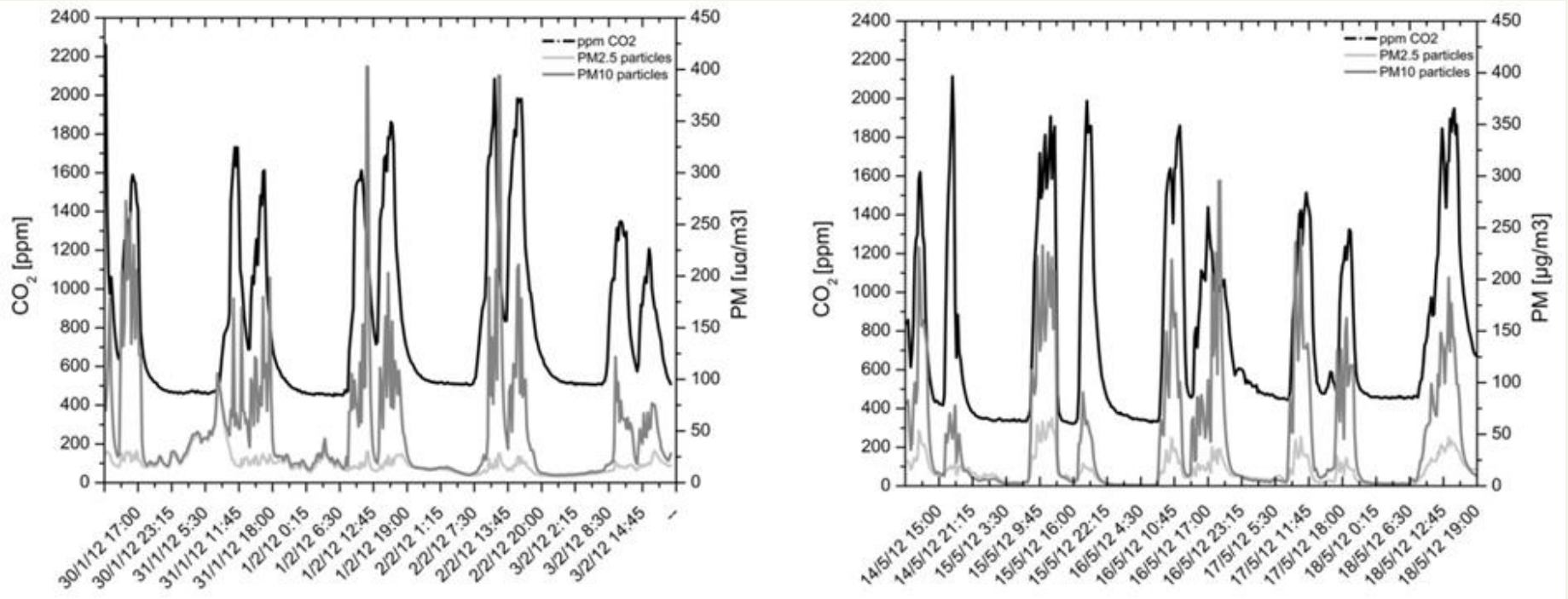
CO2 AND PM VARIATON DURING SCHOOL OCCUPANCY



- An example of PM and CO2 variation during weekday
- PM collected with Osiris monitor, CO2 measured with Testo devce

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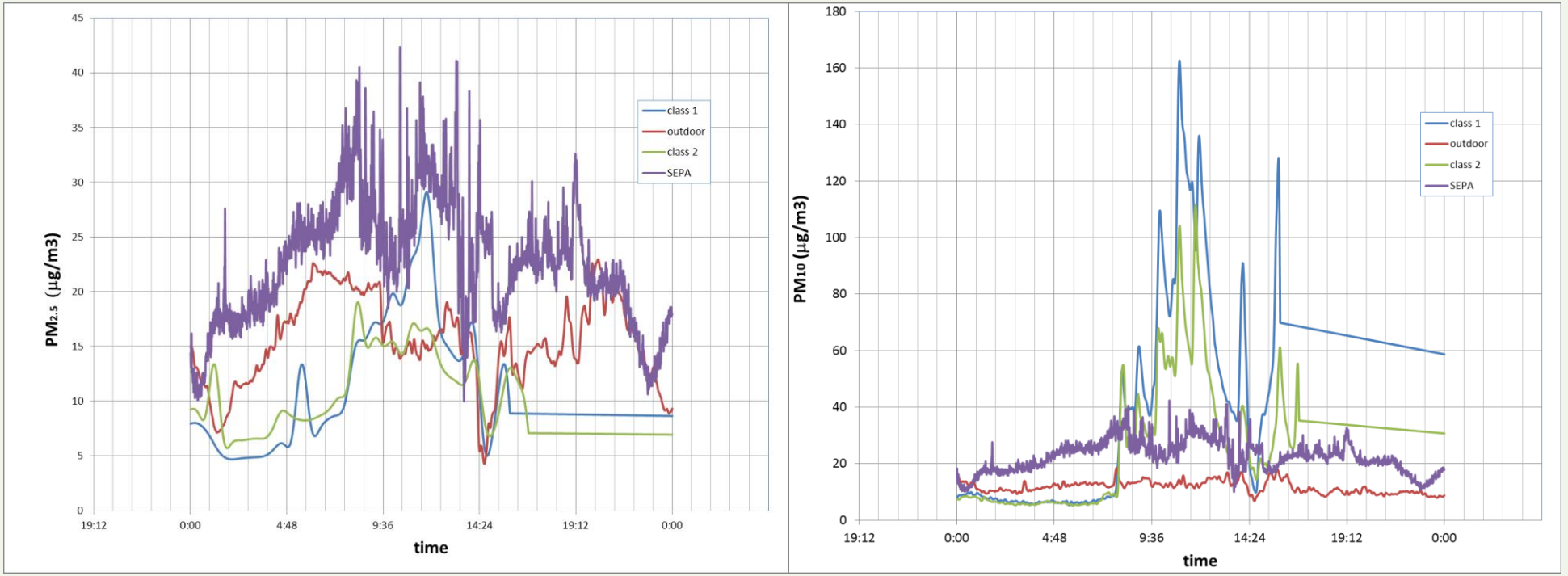
AN EXAMPLE OF PM10 AND PM2.5 DAILY VARIATION : SCHOOL INDOOR/OUTDOOR AND SEPA DATA



- April 29th 2014, school “20 oktobar”

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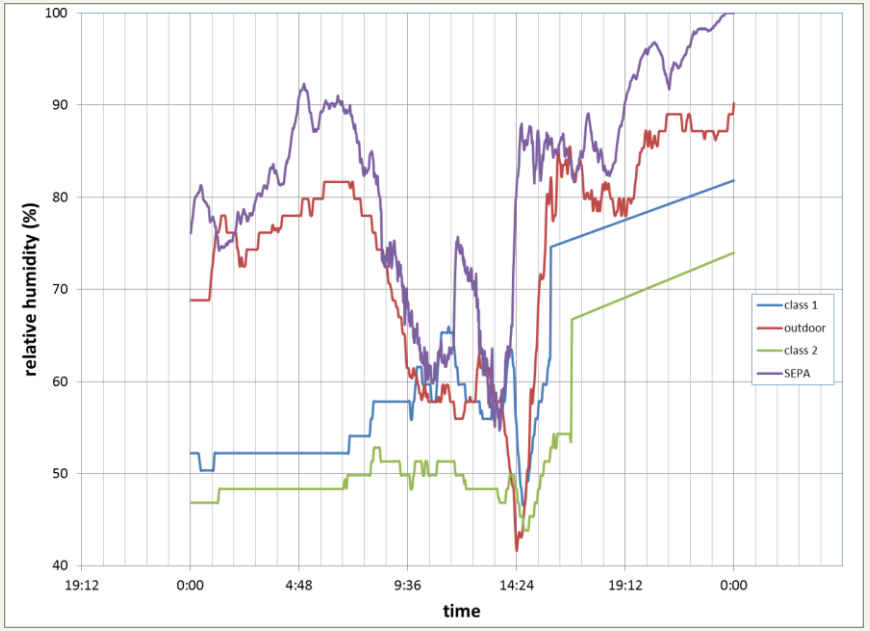
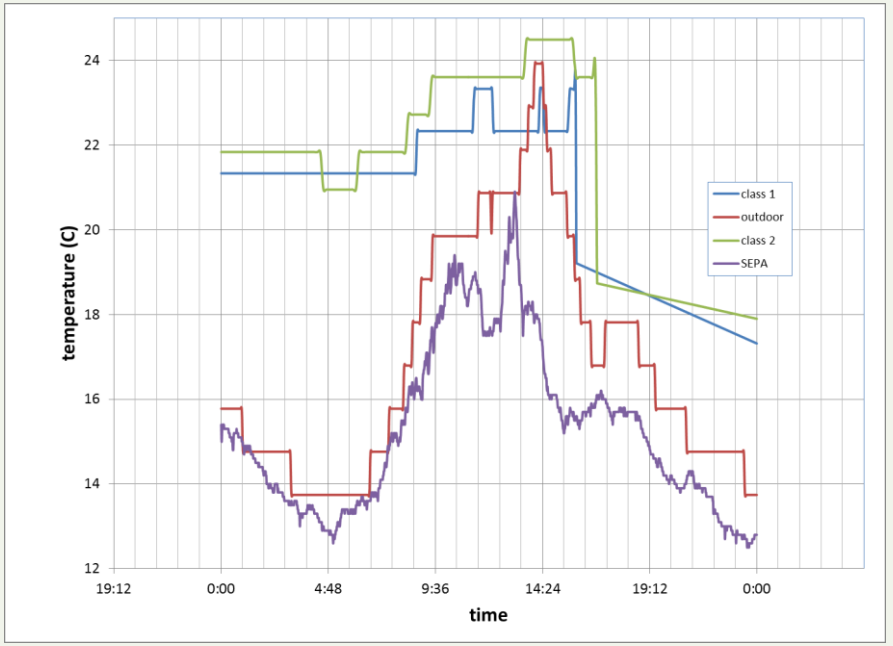
AN EXAMPLE OF HUMIDITY DAILY VARIATION: SCHOOL INDOOR/OUTDOOR AND SEPA DATA





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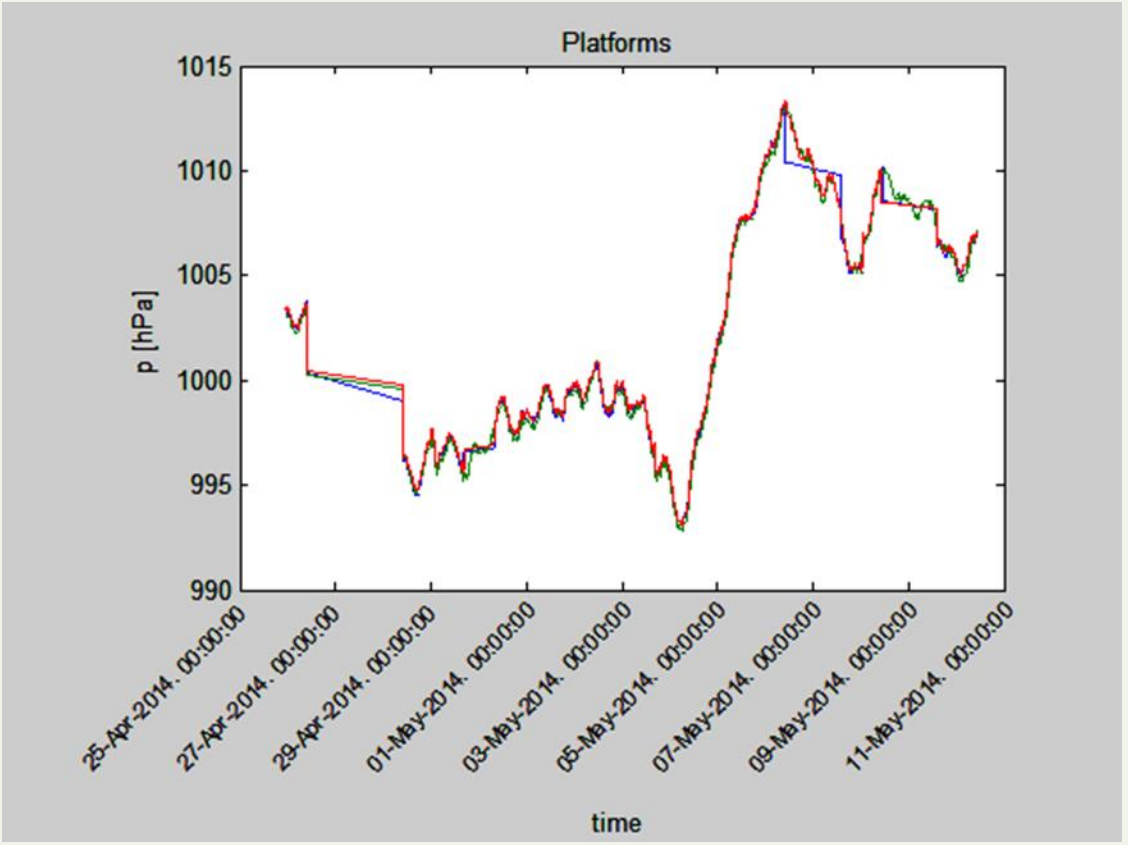
PRESSURE INDOOR/OUTDOOR MASUREMETS AT SCHOOL



Green –outdoor, Blue and red – Classrooms

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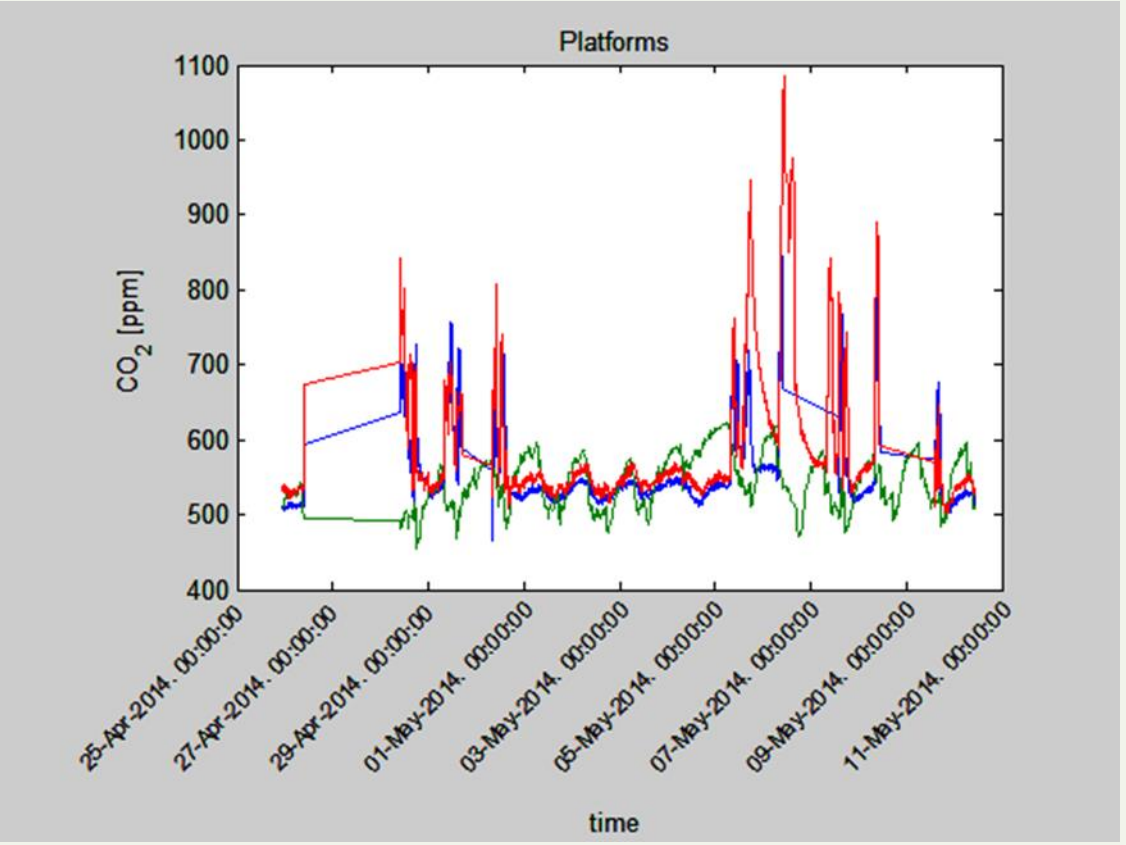
CO2 INDOOR/OUTDOOR MASUREMETS AT SCHOOL



Green –outdoor, Blue and red – Classrooms

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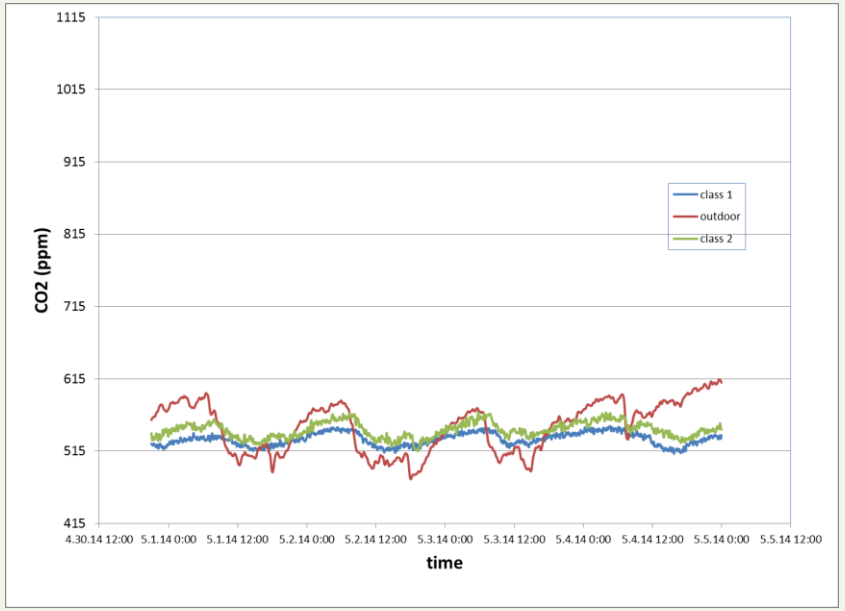
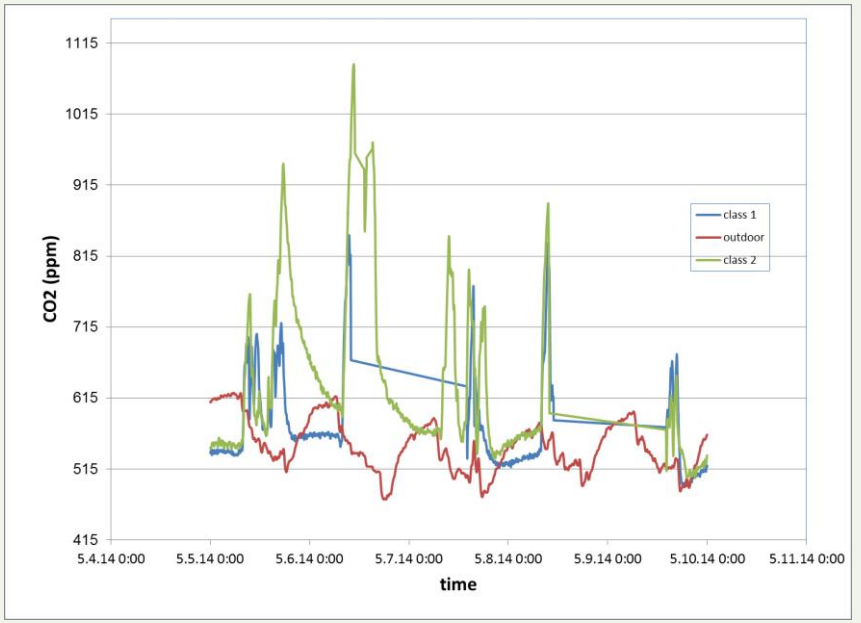
AN EXAMPLE OF C02 DAILY VARIATION : SCHOOL INDOOR/OUTDOOR WEEKAY AND WEEKEND





- April 25th-30th 2014, nonoccupied school “20 oktobar”
- May 1st -5th 2014, occupied school “20 oktobar”

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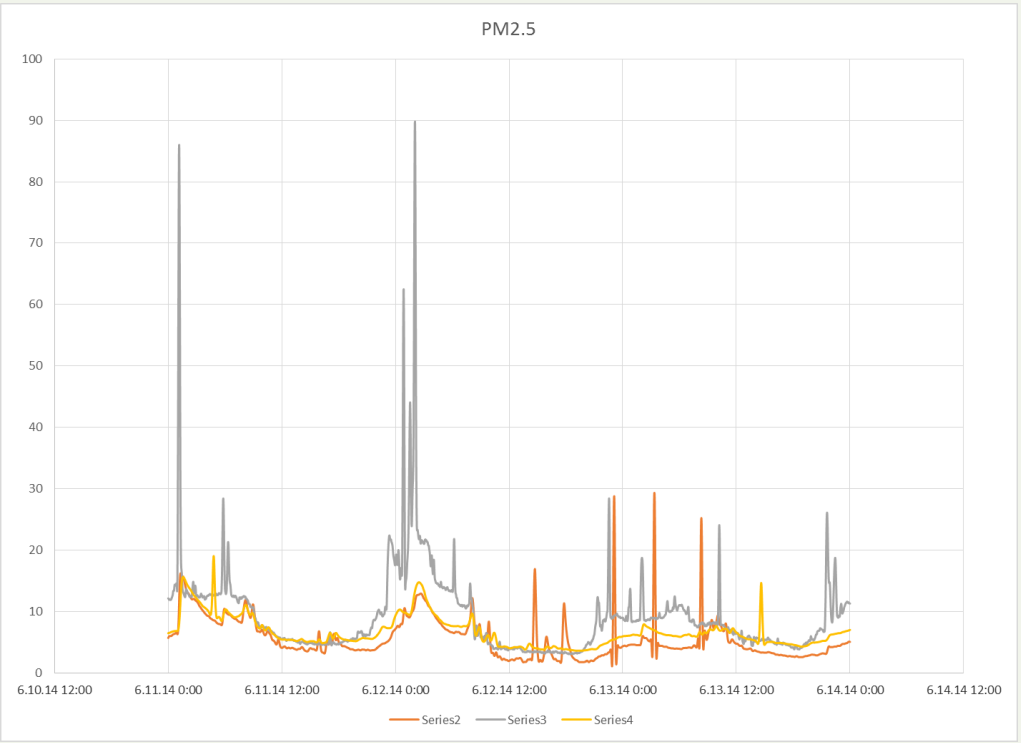
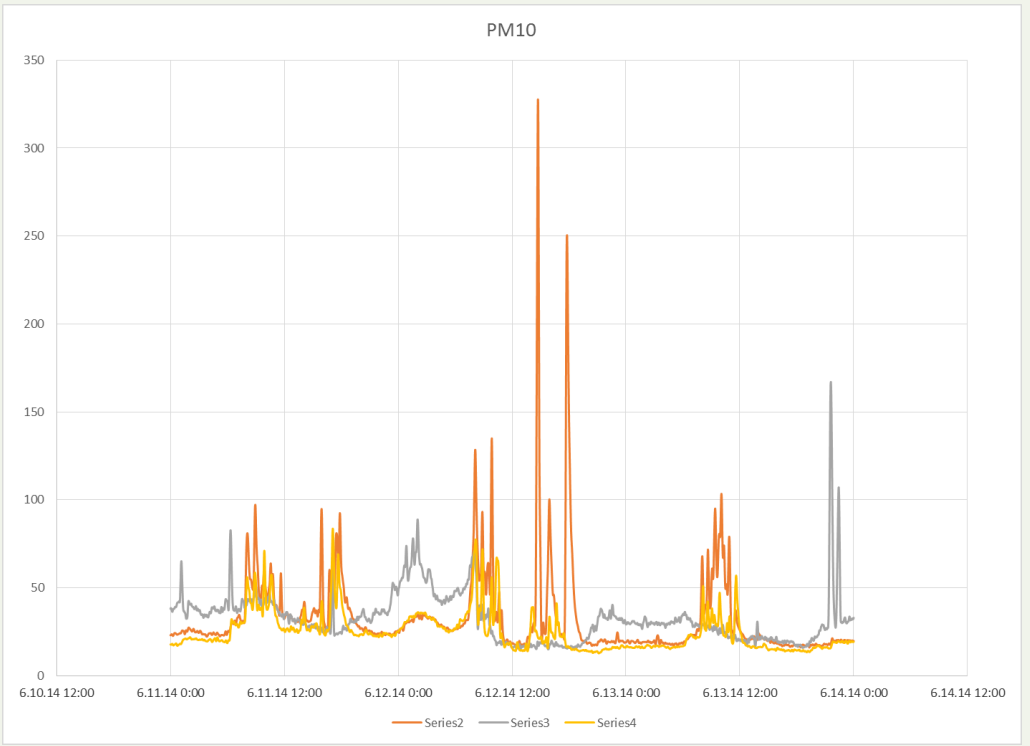
AN EXAMPLE OF PM10 AND PM2.5 DAILY VARIATION : SCHOOL INDOOR/OUTDOOR AN





SERIA 2 – INDOOR, SERIA 3 – OUTDOOR, SERIA 4 -INDOOR

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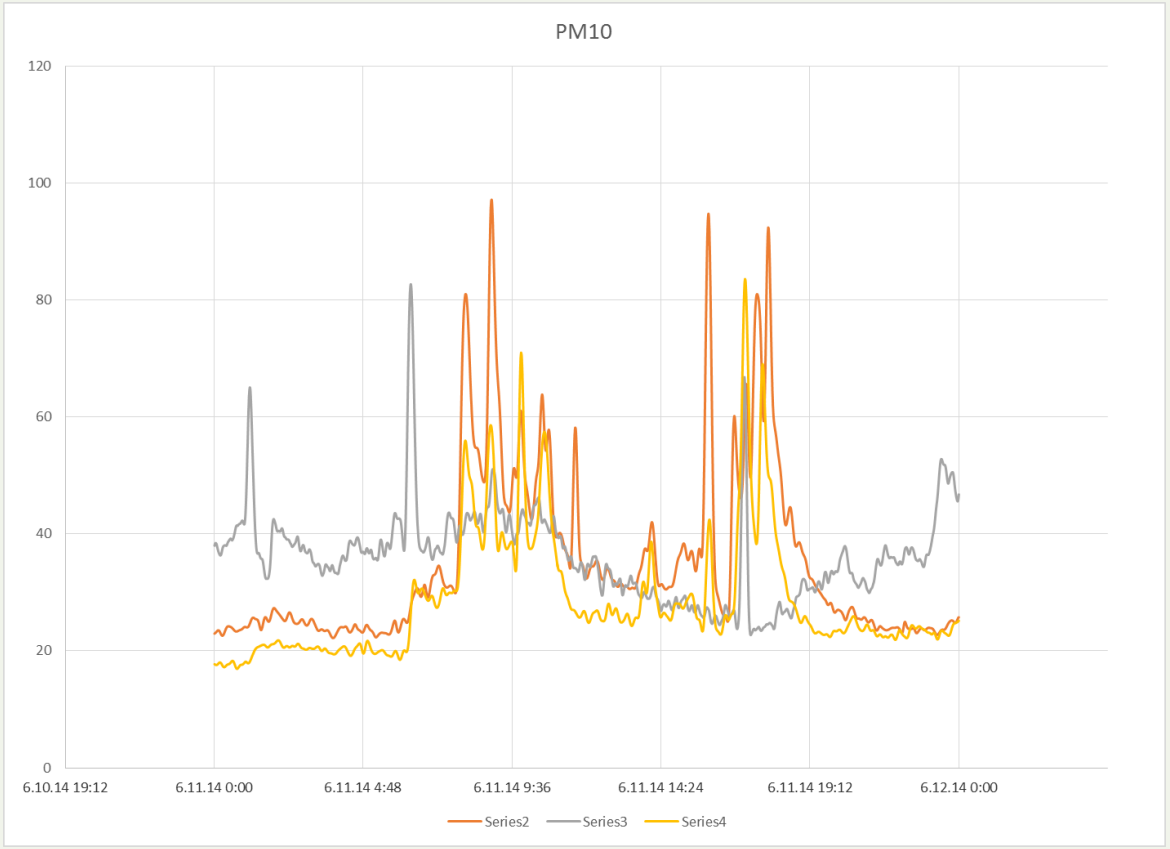
AN EXAMPLE OF PM10 DAILY VARIATION : SCHOOL INDOOR/OUTDOOR AN



SERIA 2 – INDOOR, SERIA 3 – OUTDOOR, SERIA 4 -INDOOR

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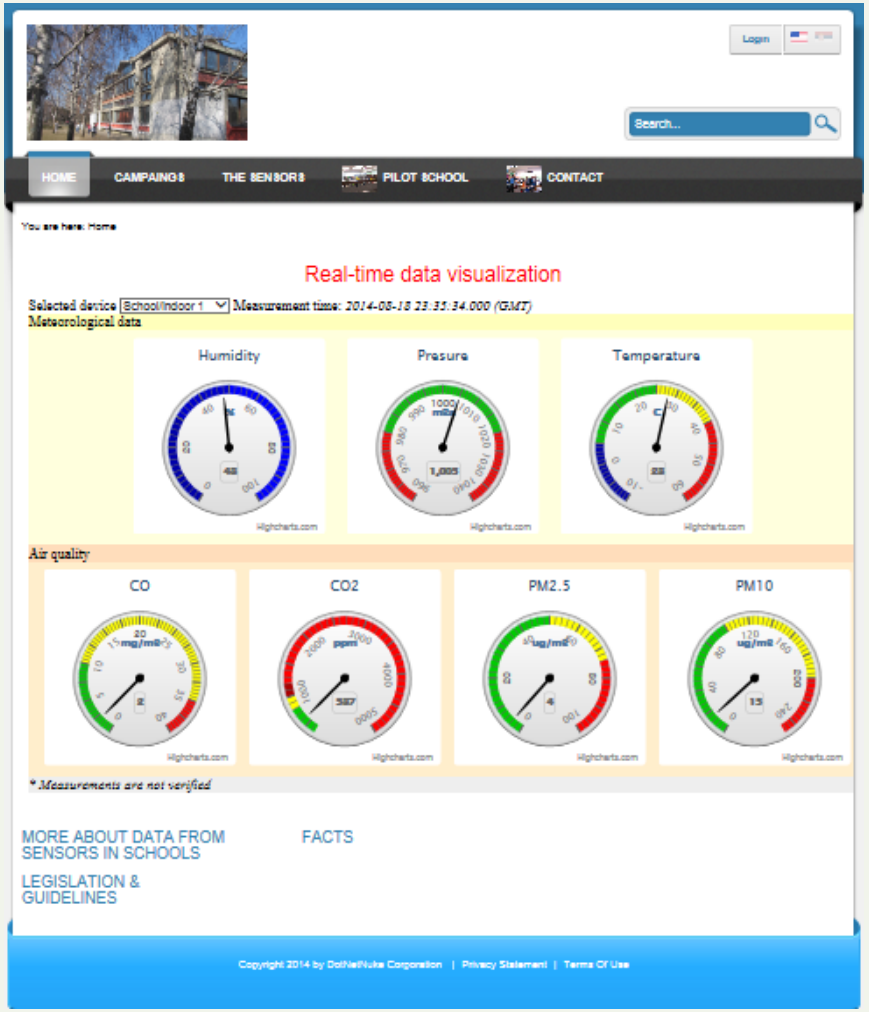
DATA VISUALISATION FOR CITI-SENSE SCHOOL PILOT STUDY IN BELGRADE



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MOBILE DESIGN SIZERS THAT COVER RESPIRABLE PM RANGE

OPS TSI MODEL 3330

Price	>10000 EUR
Particle range	0.3-10 μm
Sized channels	up to 16
Gravimetric sampling	removable 37 mm cartridge
Operational temperature	0 to 45 C
Weight	~ 2 kg

Nanoparticle sizer TSI SMPS MODEL 3910

Price	> 25000 EUR
Particle range	0.01-0.42 μm
Sized channels	13
Operational temperature	0 to 30 C
Weight	< 8 kg

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LOW COST PM DEVICE DYLOS DC1700 PRO

DC1700

- Price 200-300 EUR
- On screen display
- Real time monitoring
- of two sized channels 0.5-2.5 μm and > 2.5 μm
- Weight 2.5 lb
- Dimensions 177.9x11.3x76.2 mm
- Power 4.5 W

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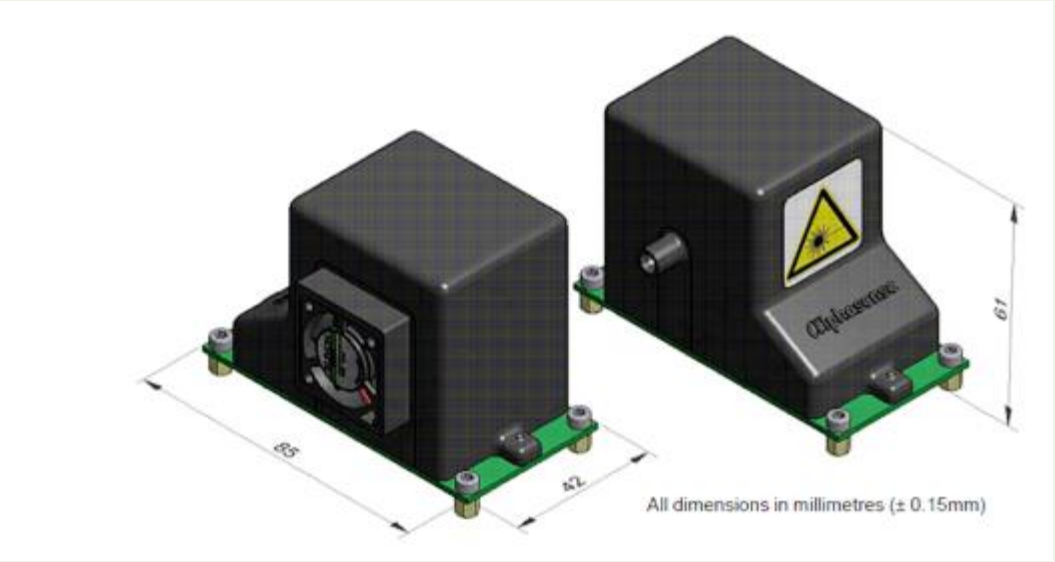
LOW COST PM DEVICE ALPHASENSE OPC-N1



Price	~ 400 EUR
Particle range	0.38-17 μm
Size category	16
Temperature range	-10 to 50 C
Weight	< 70 g

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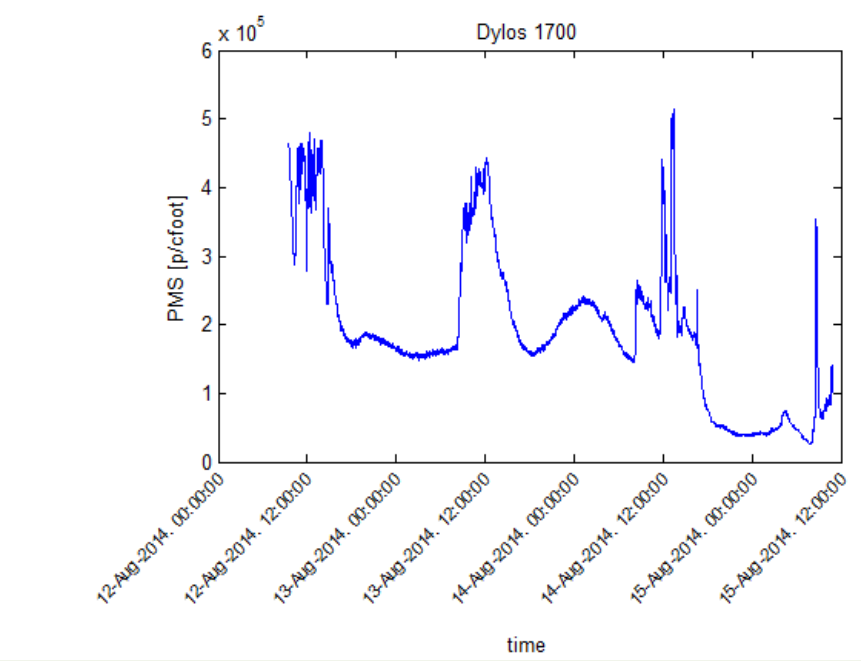
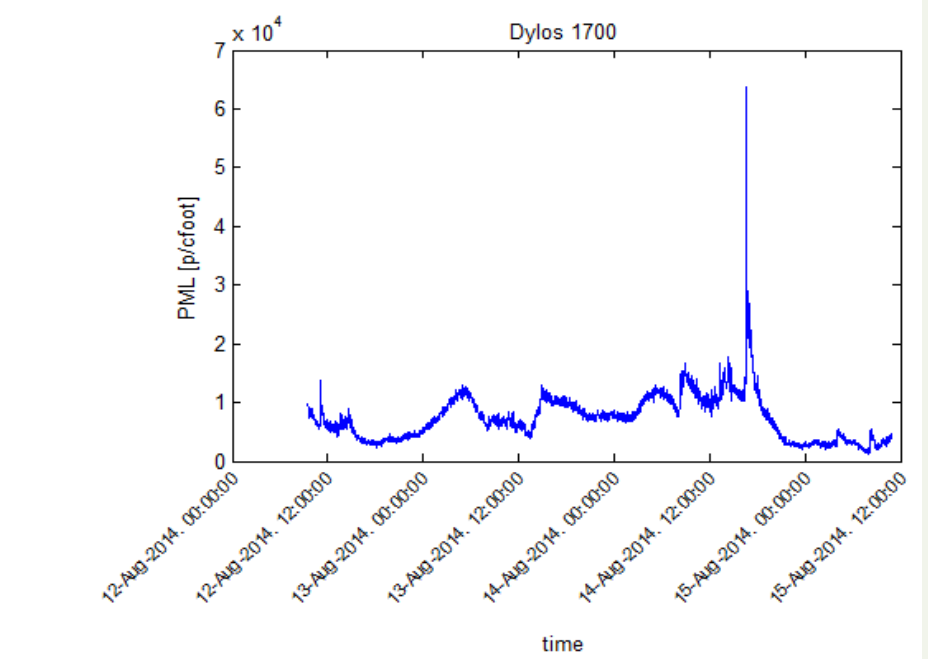
DYLOS 1700 PRO: PMS AND PML CHANEL COUINT





Real time monitoring of small fraction: 0.5-2.5 μm

Real time monitoring of large fraction: > 2.5 μm

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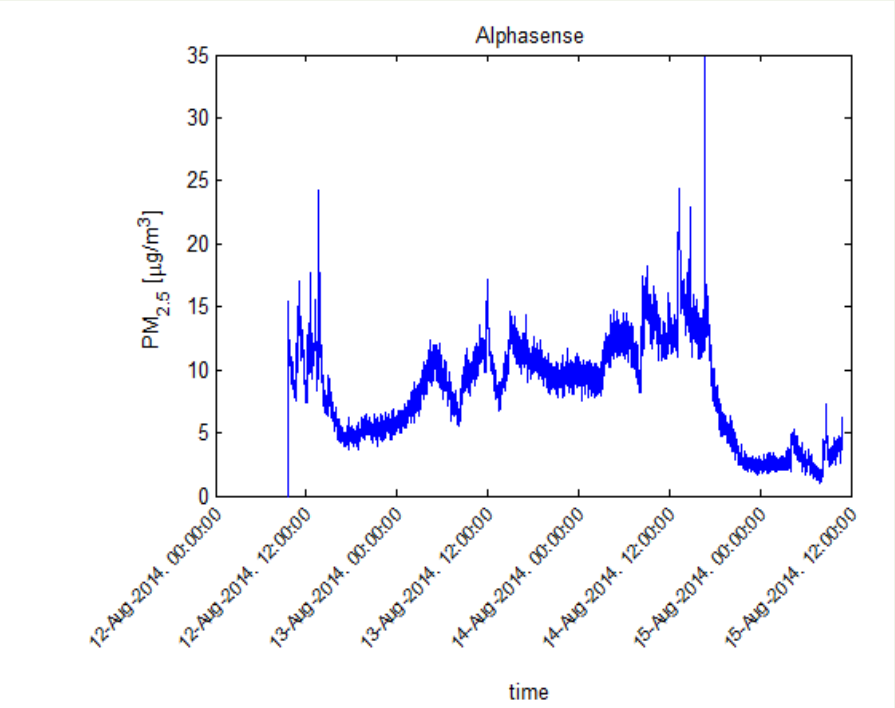
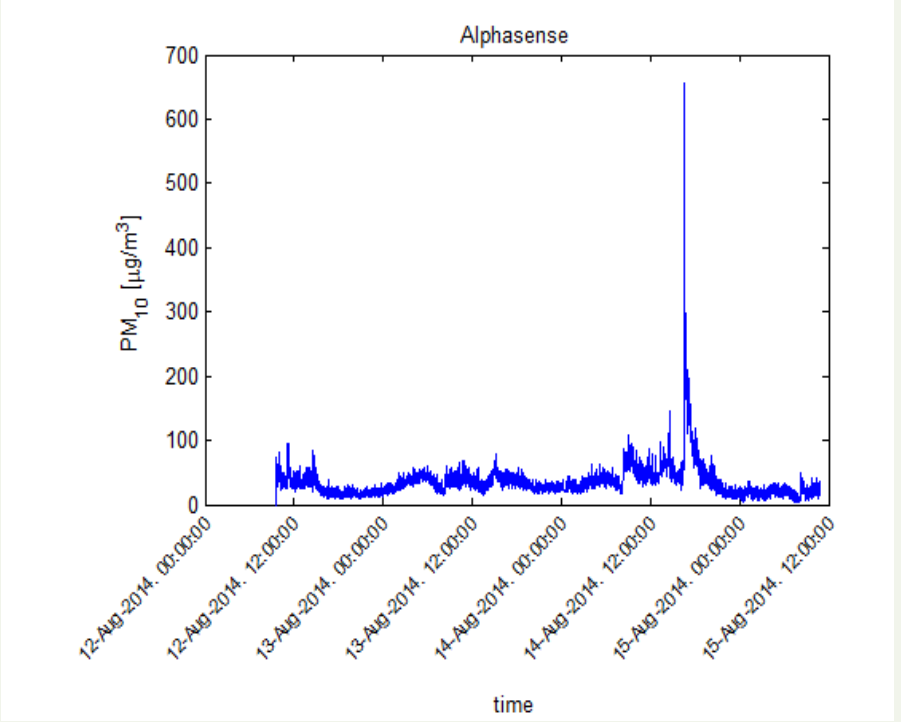
ALPHASENSE OPC-N1: PM FRACTONS <2.5 AND >2.5 μm



Real time monitoring of small fraction: 0.4-2.5 μm



Real time monitoring of large fraction: > 2.5 μm

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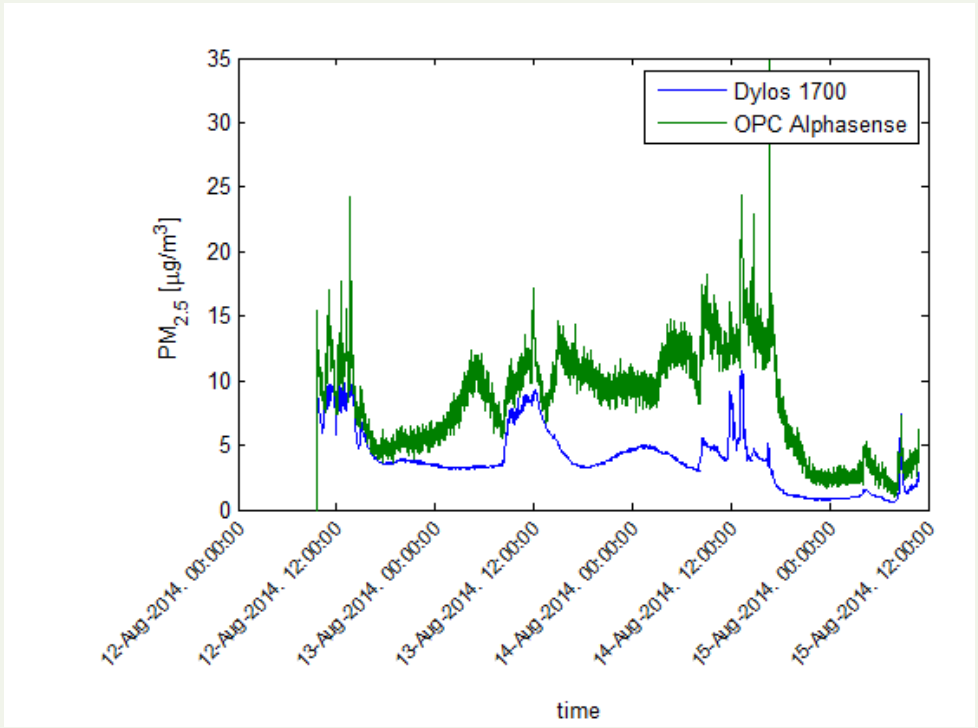
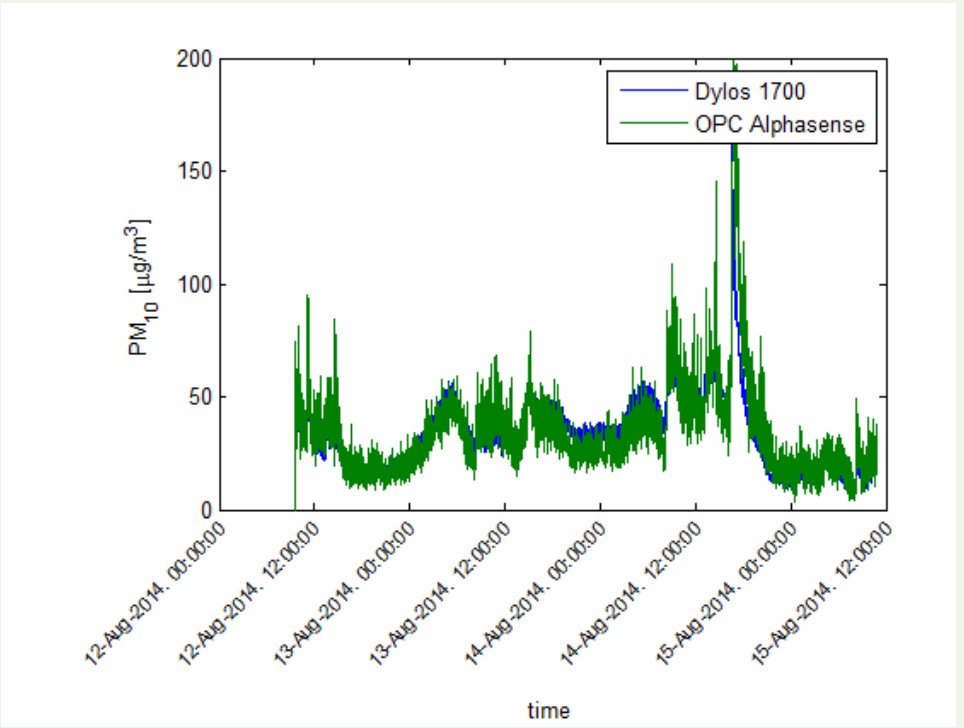
COMPARISION OF ALPHASENSE OPC-N1: AND DYLOS 1700 PRO



Real time monitoring of small fraction: < 2.5 µm



Real time monitoring of large fraction: > 2.5 µm

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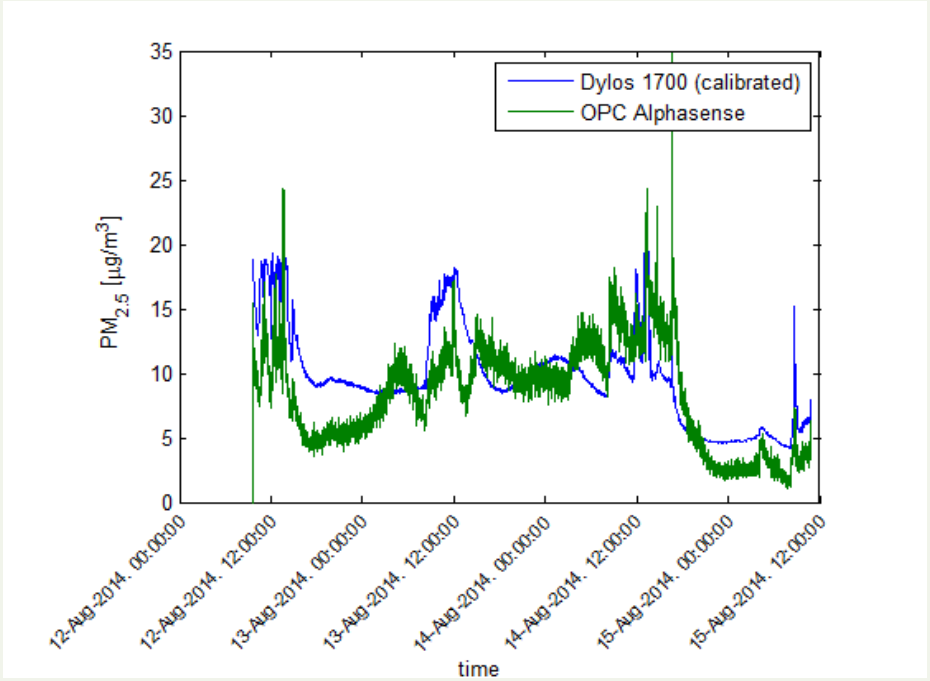
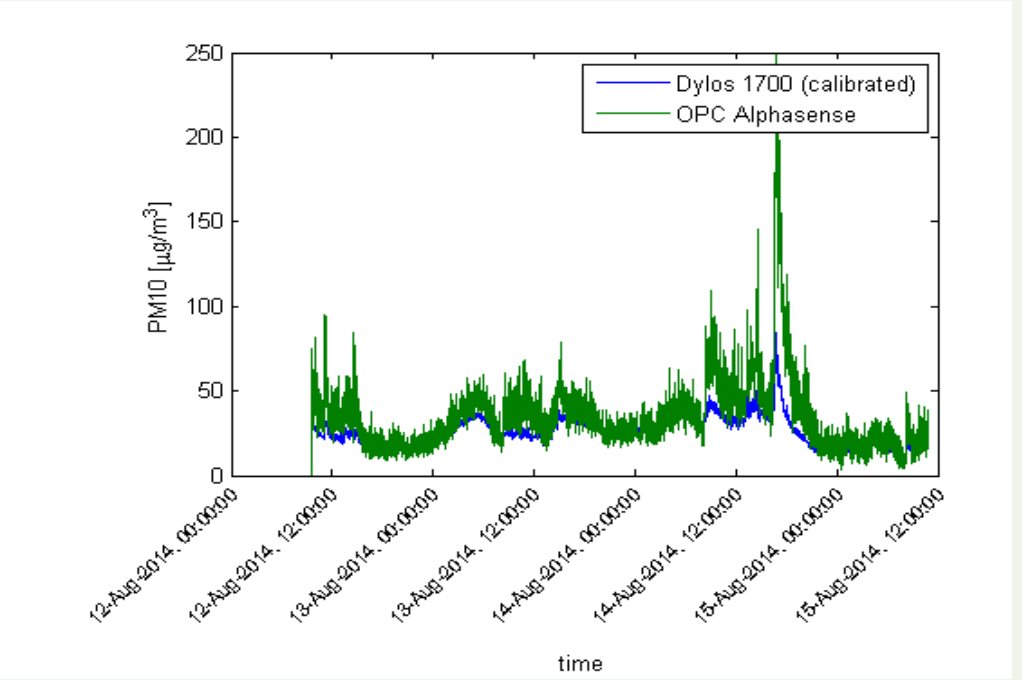
COMPARISION OF ALPHASENSE OPC-N1: AND DYLOS 1700 PRO CALIBRATED DATA



Real time monitoring of small fraction: < 2.5 μm



Real time monitoring of large fraction: > 2.5 μm

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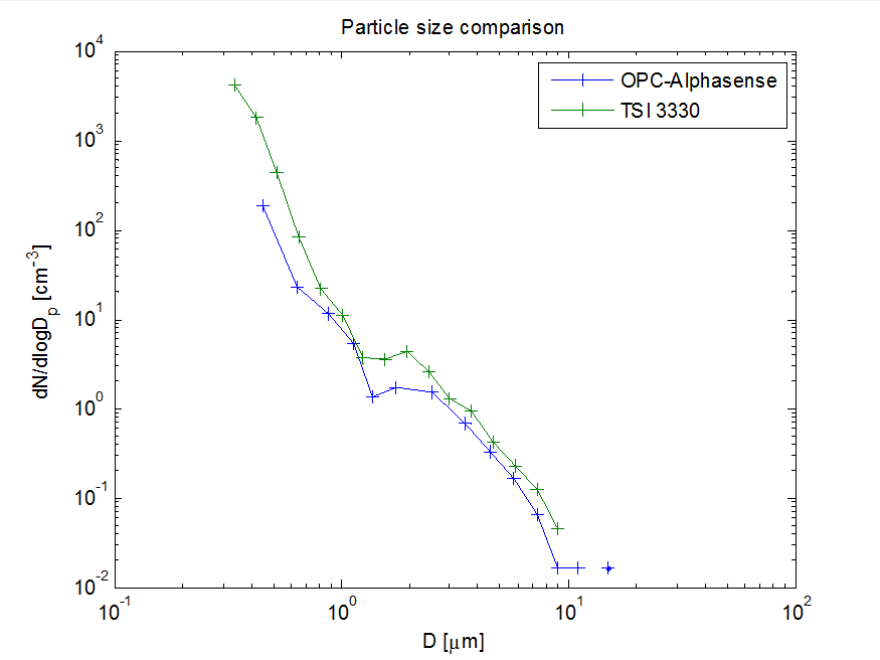
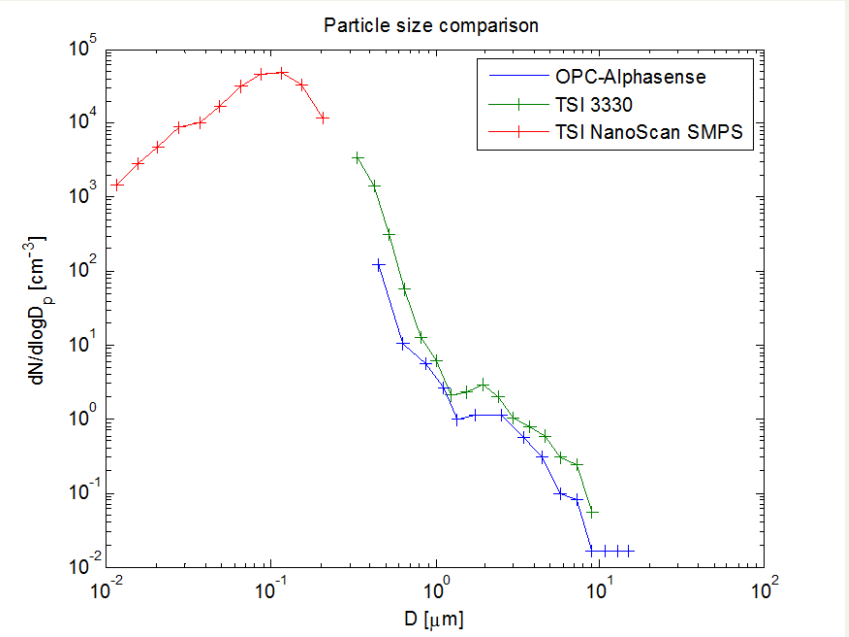
CORRELATION BETWEEN ALPHASENSE OPC-N1, TSI 3330 AND TSI 3910





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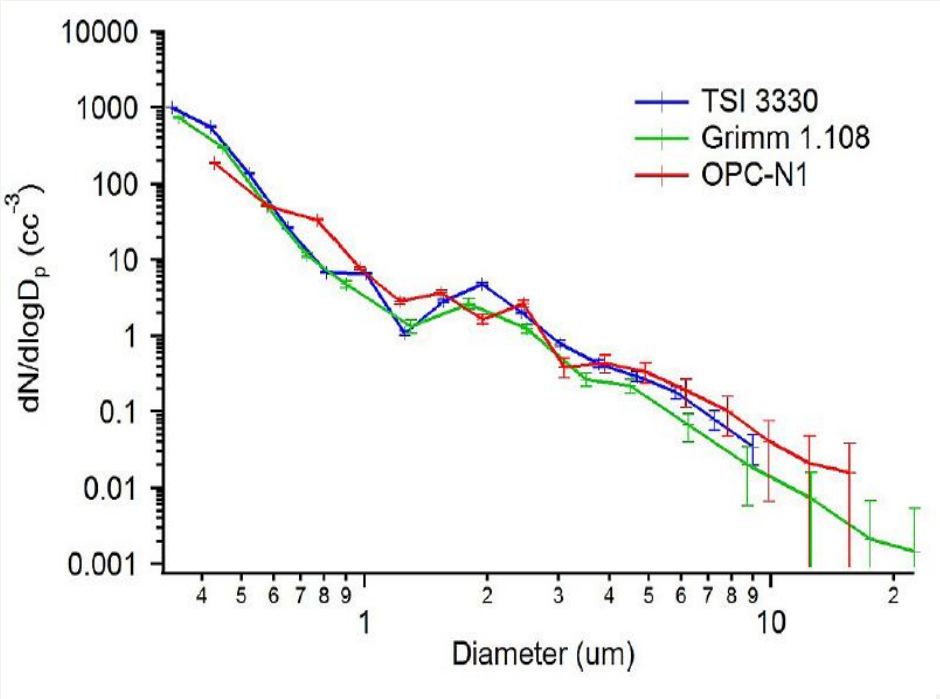
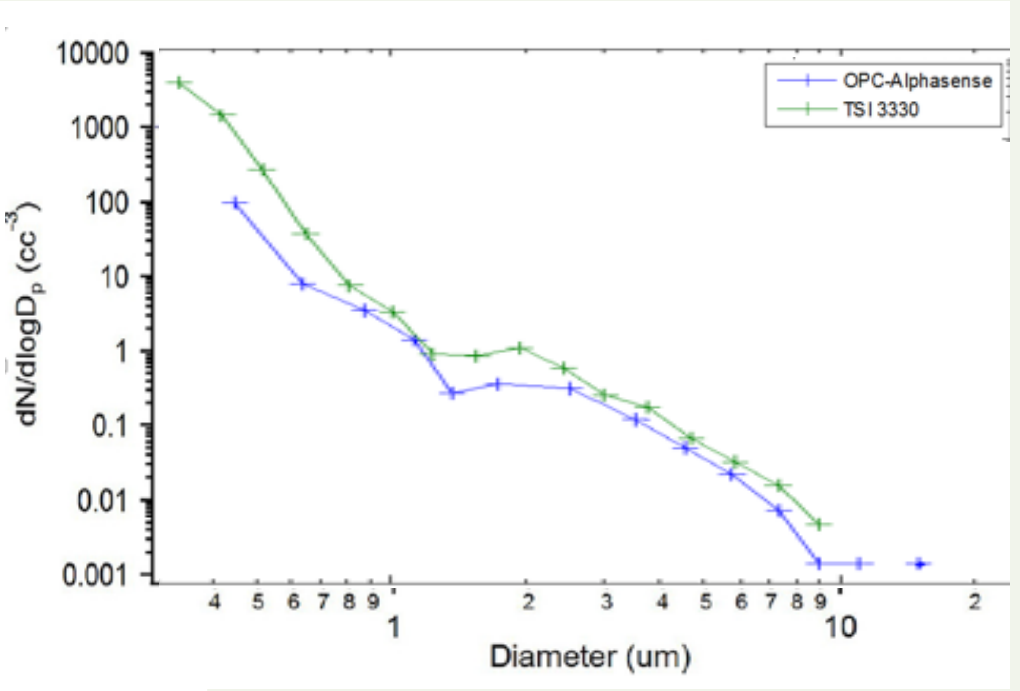
CORRELATION BETWEEN ALPHASENSE OPC-N1 AND TSI 3330





OPC-N1 PERFOERMANCE DATA,
*www.apollounion.com/Upload/.../Upload_DownFiles_**OPC-N1**.pdf*

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FURTHER ACTIVITIES FOR IAQ IN SCHOOLS

- For full deployment CITI-SENSE indoor case study in school we are going to use an new unit where it will be sensors produced by Alphasense for both, gases and PM
- Beside gases and PM in full deployment we are going to monitor important stressors such there are noise and radon in near real time
- To update methodology of calibration in the field
- To compare results from different available unit in the aim of finding optimal solution for analyzing and presenting indicative levels of pollutant and other stressors
- To create tools for exposure assessment to selecting pollutants in school microenvironment
- To create data presentation to be useful for education of wide population of schoolchildren about importance of IAQ

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