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EVALUATION OF MONITORING PM WITH LOW-COST MONITOR AND CONVENTIONAL DEVICES

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Application of low-cost sensors/platforms in Belgrade

AQMesh,

Geotech (UK)

EB700

Dubavnet (Serbia)

CITI-SENSE Beograd

LEO

ATEKNEA (Spain)

ATMOSPHERIC Platform

ATMOSHERIC SENSORS (UK)

2nd EuNetAir Air Quality Joint-Exercise

ATM in city center of Belgrade –Stari Grad

On 12 October 2015 started the 2nd EuNetAir Air Quality Joint-Exercise -Intercomparison organized by Vinča Institute where there were installed at ATM in city center of Belgrade platforms that are develop by ENEA (Italy) and Aristotle University of Thessaloniki (Greece). Two weeks after there were added devices sent by CSIC (Spain). At ATM there were also installed devices that Institute Vinča used for CITI-SENSE research activates. In duration of 4 weeks at ATM in city center of Belgrade 7 different platforms and sensors collected air pollution data.

Background

Air pollution stems from both anthropogenic and natural emissions that undergo further changes in the atmosphere.

It is a mixture of mixtures, not constant in level and composition, varies through space and time.

Respirable particulate matter (RPM) components are more dangerous then other pollutants

[1] WHO, "Burden of disease from Ambient Air Pollution for 2012 - Summary of results", World Health Organization 2014., http://www.who.int/phe/health_topics/outdoorair/databases/AAP_BoD_results_ March2014.pdf , accessed February 2016.

Background

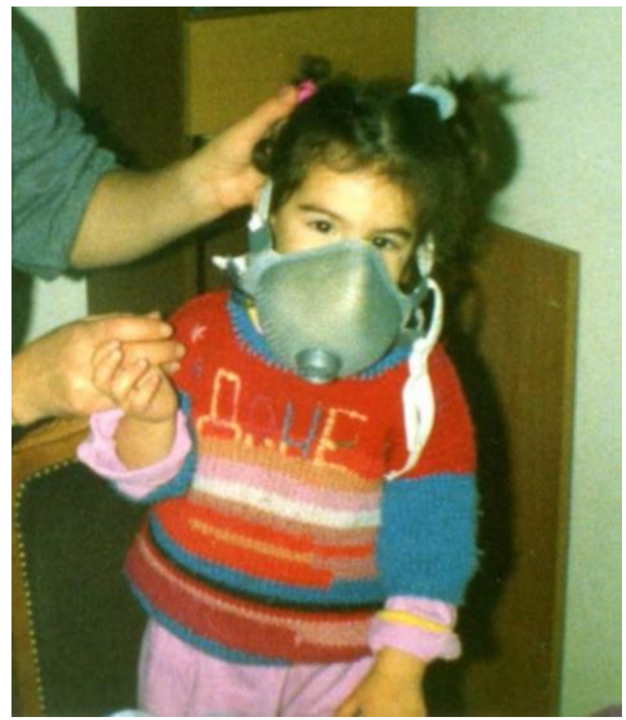
- ✓ Premature death, attributable to air pollution, happen mostly due to heart disease and stroke, followed by lung diseases and cancer, WHO (2014).
- ✓ In addition, air pollution is associated with increase in incidence of numerous additional diseases.
- ✓ The International Agency for Cancer Risk IARC designated outdoor air pollution as a Group 1 carcinogenic substance, i.e., proven human carcinogen (IACR, 2013) .
- ✓ RPM mixture, as a major component of outdoor air pollution, was evaluated separately and was also classified as carcinogenic to humans, Group 1 (IACR, 2013).

WHO, "Burden of disease from Ambient Air Pollution for 2012 - Summary of results", World Health Organization 2014., http://www.who.int/phe/health_topics/outdoorair/databases/AAP_BoD_results_ March2014.pdf , accessed February 2016.

IARC, "Outdoor air pollution a leading environmental cause of cancer deaths", Press Release No 221, 2013. https://www.iarc.fr/en/media-centre/pr/2013/index.php , accessed February 2016..

Background

There is no difference in the hazardous nature of RPM in indoor environment in comparison with those at outdoor, in the presence of indoor sources of RPM, levels of RPM fractions are usually higher than the outdoor.



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How to estimate personal exposure to RPM

Monitoring RPM in real time is essential for accurately estimating exposure RPM fraction both outdoors and indoors.

Monitoring networks at local and state level provide precise, but limited spatial coverage and not enough information for personal exposure to air pollutants including RPM.

Access to detailed air quality variations encountered when moving and spending time in different indoor and outdoor microenvironments (ME) is important for citizen in order to be more informed on how to minimize personal exposure to inhalable pollutants including PM fractions.

In near future it is expected to have information about AQ at route

Examples of PM small inexpensive monitors and sensors

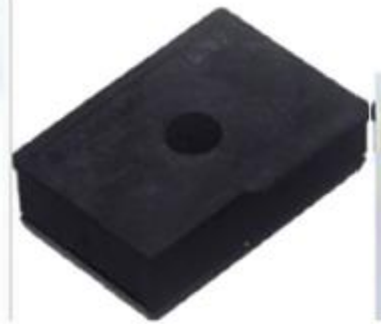
Alphasense OPC-N1

USB screen interface

Dylos Air Quality Monitor

On screen display

Sharp GP2Y1010



Shinyei PPD42NS

Need interfacing with external microcontroller and display

DYLOS monitor validation studies

- In this paper we review some recently published data about evaluation of characteristics of Dylos monitor in laboratory and in the field.
- We also present results of variability in Belgrade urban area of fine particles and coarse particles and evaluate the relationship between the level PM fractions detected with a commercially available DYLOS monitor collocated with a reference instruments at an Automatic Monitoring Station (ATM)

Testing DYLOS monitor in laboratory and field

Northcross et al (2013)

A modified Dylos monitor, BAIRS device was tested in the laboratory condition by Northcross et al. (2013).

In a chamber a controlled test atmosphere with a very wide range of aerosol concentrations were generated.

Pearson correlation coefficient with the TSI Dust Track compared with BAIRS:

- 0.99 for polystyrene latex spheres and NH_4NO_3 aerosol
- 0.97 for wood smoke particles

Northcross, A.L., Edwards, R.J., Johnson, M.A.,Wang, Z.-M., Zhu, K., Allen, T., et al., 2013. A low-cost particle counter as a realtime fine-particle mass monitor. Environ. Sci. Process. Impacts 15, 433–439.

Testing Dylos monitor colocated with reference device

Steinle et al (2015)

PNCs (particle number concentration) were transformed into $PM_{2.5}$ mass concentration based on co-location experiments:

- 5 days coolocation studies with TEOM-FDMS at ATM
- Rural site R=0.9 and at urban site R=0.7
- For previously collected data in indoor, 35 profiles were summarised in average and standard deviation per ME in PNCs and calculated $PM_{2.5}$ mass concentration.

MEs data were validated over a range of:

- 0–50 μg/m^3 with a linear function for OUTDOOR
- 0–1000 μg/m^3 with second order equation for $PM_{2.5}$ for INDOOR

Steinle, S. Reis, C. E. Sabel, S. Semple, M. M.Twigg, C. F. Braban, S. R. Leeson, M. R. Heal, D. Harrison, C.Lin, H.Wua, "Personal exposure monitoring of PM2.5 in indoor and outdoor microenvironments", Science of the Total Environment 508 (2015) 383–394.

Testing DYLOS in source specific indoor environment

Dacunto et al. (2015)

- Calibration factors of $PM_{2.5}$ DYLOS 1100 in comparison with TSI SidePak and gravimetric pump
- Test atmosphere were emissions from 17 different common indoor sources including cigarettes, incense, fried bacon, chicken, and hamburger.

Conclusion is that the Dylos might be used to provide a qualitative measure of near instantaneous $PM_{2.5}$ concentration indicating whether it is generally in a “high,” “medium,” or “low” category.

J. Dacunto, E. Klepeis, K.-C. Cheng, V. Acevedo-Bolton, R.-T. Jiang, J. L. Repace, W.R. Otta, L.M. Hildemanna, “Determining PM2.5 calibration curves for a low-cost particle monitor: common indoor residential aerosols”, Environ. Sci.: Processes Impacts, 17 (2015) 1959-1966.

DYLOS monitor integrated in EB700 platform

CITI-SENSE pilot campaign in Belgrade

- OPC DC1700, (Dylos Corp) integrated into a EB-700 platform and applied within the CITI-SENSE project pilot campaign in Belgrade
- Nine EB-700 platforms with integrated DC1700 monitor for registration air pollutants with resolution of 1 minute average concentration were available.

The air quality sensor unit

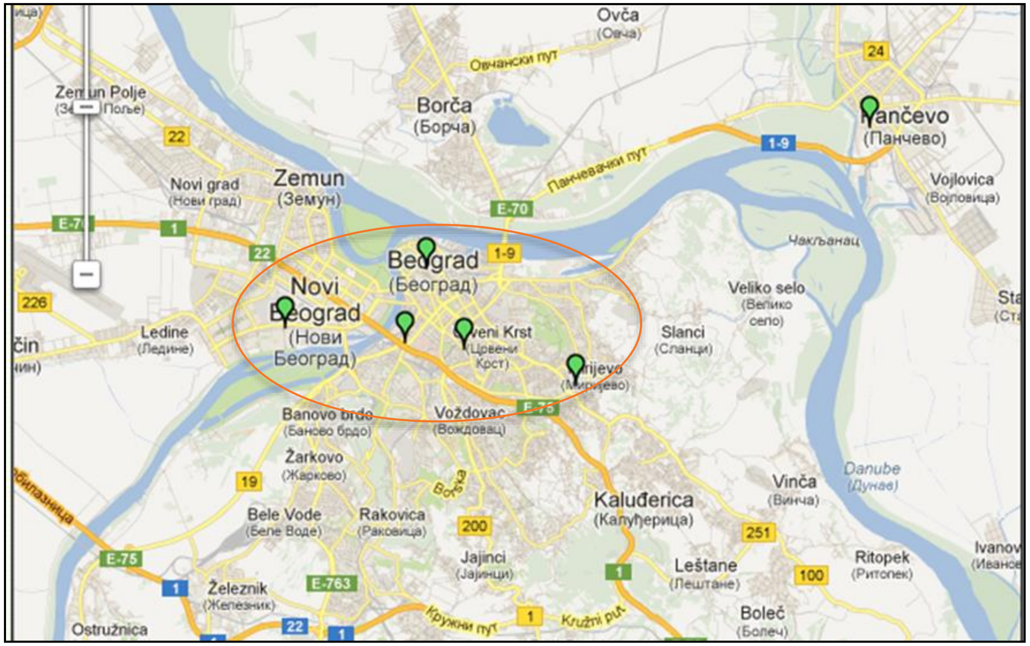
Inside the unit

DYLOS calibration in the field in Belgrade

CITI-SENSE pilot campaign in Belgrade

- All data were collected at the site of an ATM in the city center of Belgrade, Serbia, belonging to the State Network, running by SEPA.
- ATM has been equipped with Grimm monitors for PM and Thermo monitors for gases.
- 24h gravimetric mass data of PM_{10}, $PM_{2.5}$ and PM_1 collected with reference LVS samplers (provided by Institute Vinca)
- Data on ultrafine particles recorded with a TSI-CPC counter (provided by Institute Vinca) as well as with a DiscMini (provided by QUT) resolution below 1 minute

DYLOS calibration at ATM in Belgrade-location



Monitoring stations in Belgrade inner zone and in Pančevo that belong to the State network of AMTs, http://www.sepa.gov.rs/

DYLOS calibration at ATM in Belgrade-location

ATM New Belgrade

DYLOS calibration at ATM in Belgrade

CITI-SENSE pilot campaign in Belgrade

- Both reference instruments present data according to the national and EU legislation requirements, in $\mu g/m^3$
- Conservative approximation to convert DC1700 low-cost monitor counts of the two fractions $PM_{0.5\text{-}2.5}$, $PM_{2.5\text{-}10}$ into mass-concentration, (Tittarelli et al., 2008; Lee et al., 2008)

For pilot study there were two campaigns at the ATM Novi Beograd :

-at beginning, March 2014, in duration of 15 days

- and half year later October-November 2014 in duration of 10 days

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

Lee, J.Y., Shin, H.J., Bae, S.Y., Kim, Y.P., Kang, C.-H., 2008. Seasonal variations of particle size distributions of PAHs at Seoul, South Korea. Air Qual. Atmos. Health 1, 57-68.

Results and discussion of DYLOS calibration at ATM

CITI-SENSE pilot campaign in Belgrade

To quantify and compare the strengths of correlations, we used the coefficients of correlation (R) from ordinary least-squares regression models fit within nine DC1700 monitors and between low-cost devices and reference instruments.

Coefficient of correlation within the nine DC1700 was higher than 0.8 and 0.9 for fine and coarse PM fraction respectively.

Results and discussion of DYLOS calibration at ATM

CITI-SENSE pilot campaign in Belgrade

First campaign

R between each of nine DC1700 and reference PM GRIM monitor were higher than 0,90 and between 0,72 and 0.87 for PM2.5 and PM10 respectively.

Second campaign

R was for both fractions higher than 0.95 for 7 of 9 devices, and only one DC1700 register correlation less than 0.6 for PM10.

A degradation of the signals has not been noted between campaigns

CONCLUDING REMARKS FOR DYLOS 1700

- Coefficient of correlation *within* DC1700 monitors and *between* DC1700 monitors and reference PM devices in the field condition as it is traffic site were high taking in account that in all cases R were higher than 0.5.
- Next step in proving usability of a low cost PM sensors for monitoring with higher spatial and temporal resolution and usage for personal exposure assessment is comparability of data collecting at different type of ATM e.g. traffic, residential, industrial, urban background, suburban (*if any*), rural sites.
- Also DYLOS montor show promising results, during campaigns it was evidenced that the design of the DC1700 monitor has to be improved to eliminate the possibility of the fan blockage.

Thank you for your attention

www.citi-sense.eu

CITI-SENSE

CITI-SENSE Beograd

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