COST Action TD1105 *EuNetAir*

BOOKLET

THIRD INTERNATIONAL ACTION WORKSHOP

New Trends and Challenges for Air Quality Control

Faculty of Geography and Earth Sciences
Alberta Street, 10, LV-1010, Riga, Latvia

organized by University of Latvia

supported by Riga Technical University

Riga (Latvia), 26 - 27 March 2015

cost
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

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ESSEM Domain

COST Action TD1105

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

THIRD INTERNATIONAL ACTION WORKSHOP on

New Trends and Challenges for Air Quality Control

Riga (Latvia), 26 - 27 March 2015

University of Latvia, Faculty of Geography and Earth Sciences
Alberta Street, 10, LV-1010, Riga, Latvia

organized by **University of Latvia**	
supported by **Riga Technical University**	

AGENDA	
26 March 2015 - Thursday	
09:00 - 18:00	***REGISTRATION***
09:30 - 10:00	**Welcome Address**
10:00 - 11:00	**Session 1: Plenary Session**
11:00 - 11:30	*Coffee Break*
11:30 - 13:00	**Session 2: Oral Presentations**
13:00 - 14:30	*Lunch*
14:30 - 16:00	**Session 3: Oral Presentations**
16:00 - 16:30	*Coffee Break*
16:30 - 18:30	**Session 4: Oral Presentations**
20:00 - 23:00	*Social Dinner*
27 March 2015 - Friday	
09:00 - 16:00	***REGISTRATION***
09:30 - 11:00	**Session 5: Oral Presentations**
11:00 - 11:30	*Coffee Break*
11:30 - 13:00	**Session 6: Oral Presentations**
13:00 - 14:30	*Lunch*
14:30 - 16:00	**Session 7: Poster Presentations**
16:00 - 16:30	*Discussion and Coffee Farewell*
16:30	**Closure of Meeting**

COST is supported by the EU Framework Programme

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Background and goals

About COST Action TD1105 *EuNetAir*

COST Action TD 1105 EuNetAir, a Concerted Action on *New Sensing Technologies for Air-Pollution Control and Environmental Sustainability*, is a running Networking funded in the framework *European Cooperation in the field of Scientific and Technical Research* (COST) during 2012-2016.

The main objective of the Concerted Action is to develop new sensing technologies for Air Quality Control at integrated and multidisciplinary scale by coordinated research on nanomaterials, sensor-systems, air-quality modelling and standardised methods for supporting environmental sustainability with a special focus on Small and Medium Enterprises.

This international Networking, coordinated by ENEA (Italy), includes over 80 big institutions from 30 COST Countries (EU-zone: *Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Luxembourg, The Former Yugoslav Republic of Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom*) and 7 International Partners Countries (extra-Europe: *Australia, Canada, China, Morocco, Russia, Ukraine, USA*) to create a S&T critical mass in the environmental issues.

About the *3rd International Action Workshop* at University of Latvia, Riga, 26 - 27 March 2015

The **3rd International Workshop EuNetAir** on ***New Trends and Challenges for Air Quality Control*** will be held at University of Latvia, Riga (Latvia) under management of University of Latvia, and locally coordinated by Dr. Iveta Steinberga (LV MC Member). This third workshop of the Action TD1105 *EuNetAir* follows the first one organized at Barcelona, Spain (20 June 2013) as Satellite Event inside *Transducers 2013 - Eurosensors XXVII*, and the second one organized at Brindisi, Italy (25-26 March 2014).

The core-issues of the COST Action TD1105 on the **new trends and challenges** in the sensing technologies for indoor and outdoor monitoring and air quality control will be surveyed by Action partners in **visionary approach** with emphasis at *functional materials and nanotechnologies for gas sensors, low-cost and low-power chemical sensors, portable sensor-systems, sensor-instrumentations, air-pollution modelling, methods, measurements and protocols for air quality control and environmental monitoring, experimental campaigns of air quality monitoring, air-pollutants and new metrics, health-effects of air pollution, guidelines and regulations*.

Fruitful discussions between Action TD1105 participants, international experts, speakers and international institutional organizations delegates are strongly expected. At the ***Open Third Action Workshop*** of the COST Action TD1105 *EuNetAir*, a strong impact on critical environmental issues would be mutual benefit.

More Information

Dr. Michele PENZA
MC Chair/Proposer of COST Action TD1105 EuNetAir
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development
Technical Unit for Materials Technologies - Brindisi Research Centre
PO BOX 51 Br-4, I-72100 Brindisi, ITALY. Email: michele.penza@enea.it. Action webpages: www.cost.eunetair.it

Dr. Iveta STEINBERGA
MC LV Member and Local Organizing Team Chair
Faculty of Geography and Earth Sciences
University of Latvia, Riga, Latvia
Alberta Street, 10, LV-1010, Riga, LATVIA
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Dr. Gita SAKALE
MC LV Member and Local Organizing Team Co-Chair
Institute of Technical Physics
Riga Technical University
Paula Valdena Street 3, LV-1048, Riga, LATVIA
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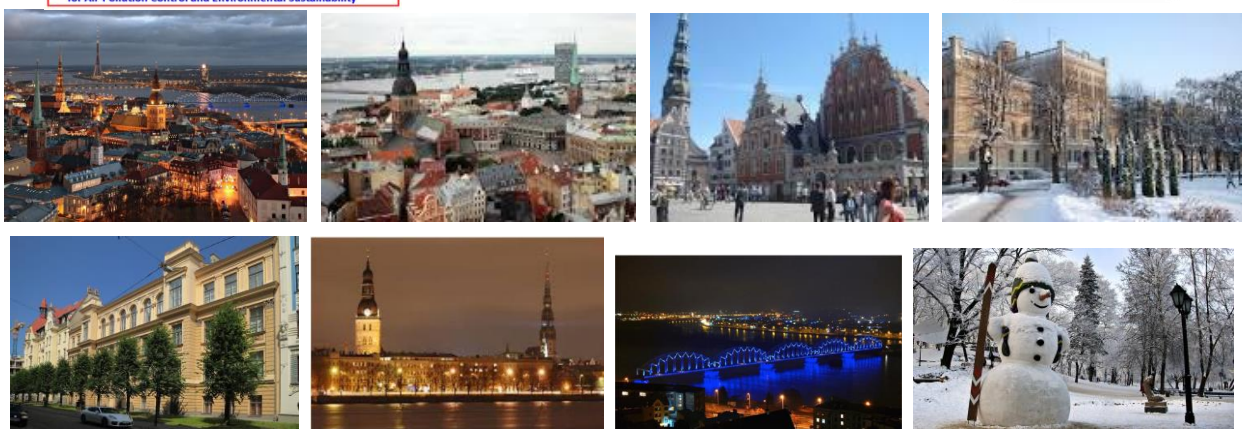
THIRD INTERNATIONAL ACTION WORKSHOP on

New Trends and Challenges for Air Quality Control

Riga (Latvia), 26 - 27 March 2015

University of Latvia, Faculty of Geography and Earth Sciences
Alberta Street, 10, LV-1010, Riga, Latvia



Action Workshop Programme Committee

Michele Penza, ENEA, Brindisi, Italy
Anita Lloyd Spetz, Linkoping University, Sweden
Iveta Steinberga, University of Latvia, Riga, Latvia
Gita Sakale, Riga Technical University, Riga, Latvia
Andreas Schuetze, Saarland University, Germany
Zafer Ziya Ozturk, GEBZE Institute of Technology, Turkey
Carlos Borrego, IDAD, University of Aveiro, Portugal
Ole Hertel, Aarhus University, Denmark
Ingrid Bryntse, SenseAir AB, Sweden
Juan Ramon Morante, IREC, Spain
Marco Alvisi, ENEA, Italy
Corinna Hahn, Eurice GmbH, Saarbrucken, Germany
Juliane Rossbach, Eurice GmbH, Saarbrucken, Germany
Annamaria Demarinis Loiotile, University of Bari, Italy
Sanda Palapa, University of Latvia, Riga, Latvia
Sandra Vesere, University of Latvia, Riga, Latvia
Sandra Guzlena, Riga Technical University, Riga, Latvia

URL: www.cost.eunetair.it

COST Action TD1105 EuNetAir Steering Committee

Michele Penza, ENEA, Brindisi, Italy - *Action Chair*
Anita Lloyd Spetz, Linkoping University, Sweden - *Action Vice-Chair*
Juan Ramon Morante, IREC, Spain
Andreas Schuetze, Saarland University, Germany
Ole Hertel, Aarhus University, Denmark
Ingrid Bryntse, SenseAir AB, Sweden
Jan Theunis, VITO, Belgium
Marco Alvisi, ENEA, Brindisi, Italy
Gianluigi De Gennaro, University of Bari, Italy
Fabio Galatioto, Newscastle University, UK
Ralf Moos, University of Bayreuth, Germany
Mar Viana, CSIC-IDAEA, Barcelona, Spain
Iveta Steinberga, University of Latvia, Riga, Latvia
Corinna Hahn, Eurice GmbH, Saarbrucken, Germany - *Grant Holder*
Julian Gardner, University of Warwick, UK
Rod Jones, University of Cambridge, UK
Giorgio Sberveglieri, University of Brescia, Italy
Eduard Llobet, Universitat Roviri I Virgili, Tarragona, Spain
Thomas Kuhlbusch, IUTA eV, Duisburg, Germany
Albert Romano-Rodriguez, Universitat de Barcelona (UB), Spain
Carlos Borrego, IDAD, University of Aveiro, Portugal
Annamaria Demarinis Loiotile, University of Bari, Italy - *Secretary*

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Thursday, 26 March 2015

COST Action TD1105 EuNetAir WORKSHOP

Faculty of Geography and Earth Sciences, University of Latvia
Alberta Street, 10, LV-1010 Riga, Latvia

09:00 - 18:00	**COST Event Registration**
09:30 - 10:00	***Welcome Address*** *Chairperson: Iveta Steinberga, Local Organizing Committee Chair and MC LV Member - University of Latvia, Riga, Latvia*
	Welcome: Delegate of Riga City Council *Janis Kleperis*, Member of Riga City Council, Latvia
	Welcome: University of Latvia *Maris Klavins*, Chairman University of Latvia Senate, Riga, Latvia
	Welcome: Riga Technical University *Talis Juhna*, Vice-Rector for Research, Riga Technical University, Riga, Latvia
	Welcome: COST Action TD1105 *EuNetAir* *Michele Penza*, Action Chair, ENEA, Brindisi, Italy
10:00 - 11:00	***Session 1 - Plenary Session*** *Chairperson: Michele Penza, Action Chair - ENEA, Brindisi, Italy*
10:00 - 10:30	**COST Action TD1105: European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability. Overview and Plans of COST Action TD1105** *Michele Penza*, Action Chair, ENEA, Brindisi, Italy
10:30 - 11:00	**Health Effects of Air Pollution in Europe** *Michal Krzyzanowski*, Former Head WHO European Centre for Environment and Health, Bonn Office, Germany - Honorary Affiliation: Environmental Research Group, King's College London, UK
11:00 - 11:30	**Coffee Break**
11:30 - 13:00	***Session 2 - Environmental Informatics and AQ Sensors*** *Chairperson: Carlos Borrego, IDAD and University of Aveiro, Aveiro, Portugal*
11:30 - 12:00	**CMOS Sensor Systems for Air Quality Monitoring** *Foysol Chowdhury*, Action WG Member, CCMOSS Ltd, Cambridge, UK
12:00 - 12:20	**Preprocessing, Analyzing and Modeling of Air Quality Measurement Data** *Kostas Karatzas*, Aristotle University of Thessaloniki, Greece
12:20 - 12:40	**Towards Personal Exposure Estimates Using Low-Cost Air Quality Sensors and Data Fusion Techniques** *Philipp Schneider*, Action MC Member, NILU, Kjeller, Norway
12:40 - 13:00	**Air Quality Modelling and Chemical Weather Forecasting at Different Scales** *Camillo Silibello*, Project manager, ARIANET srl, Milan, Italy
13:00 - 14:30	**Lunch Break**

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14:30 - 16:00	***Session 3 - Methods and Applications for Environmental Sustainability*** *Chairperson: Hans-Guido Muecke*, WHO Collaborating Centre for Air Quality Management and Air Pollution Control - Federal Environment Agency, Berlin, Germany
14:30 - 15:00	**"What Can Be Done When Pollutants Are in the Air ?"** *Stanislaw W. Gawronski,* Warsaw University of Life Science, Warsaw, Poland
15:00 - 15:20	**The 1st EuNetAir Air Quality Joint-Exercise Intercomparison: Assessment of Micro-Sensors versus Reference Methods** *Carlos Borrego*, IDAD and University of Aveiro, Aveiro, Portugal
15:20 - 15:40	**Air Pollution Modelling for Regulatory Purposes: Riga Case-Study** *Iveta Steinberga, Aiva Eindorfa, Oskars Stulbergs*, University of Latvia, Riga, Latvia
15:40 - 16:00	**Making Visible the Invisible: Communicating Air Quality** *Nuria Castell-Balaguer*, NILU - Norwegian Institute for Air Research, Kjeller, Norway
16:00 - 16:30	**Coffee Break**
16:30 - 18:30	***Session 4 - Modelling and Applications for Air Quality Control*** *Chairperson: Iveta Steinberga*, University of Latvia, Riga, Latvia
16:30 - 16:50	**Performance of Bulgarian WRF-CMAQ Modeling System** *E. Georgieva, D. Syrakov, M. Prodanova, I. Etropolska, K. Slavov*, Bulgarian Academy of Sciences, Sofia, Bulgaria
16:50 - 17:10	**Air Quality Control in Hungary: Recent Changes** *Krisztina Labancz*, Hungarian Meteorological Service, Budapest, Hungary
17:10 - 17:30	**On a Multilevel Parametric CFD Model for Urban Air Pollution Modelling** *Zoltan Horvath*, Department of Mathematics and Computational Sciences, Szechenyi Istvan University, Gyor, Hungary
17:30 - 17:50	**Review of Ambient Particulate Matter Levels and Source Contribution in Serbia** *Milena Jovasevic-Stojanovic1*, *Anka Cvetkovic2*, *Viša Tasić3*; 1) Action MC Member, Institute Vinca, Belgrade, Serbia; 2) Public Health Institute; 3) Mining and Metallurgy Institute Bor, Serbia
17:50 - 18:10	**The MOSSClone FP7 project: Monitoring Air Quality using Moss as Passive Sensor** *José Angel Fernández Escribano*, Project Coordinator, Facultad de Biología, Universidade de Santiago de Compostela (USC), Santiago de Compostela, Spain
18:10 - 18:30	**Kernel Networks for Learning from Sensory Data** *Roman Neruda*, *Vera Kurkova*, Institute of Computer Science, Academy of Sciences of the Czech Republic, Prague, Czech Republic
20:00 - 23:00	**Social Dinner**

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Friday, 27 March 2015

COST Action TD1105 EuNetAir WORKSHOP

Faculty of Geography and Earth Sciences, University of Latvia
Alberta Street, 10, LV-1010 Riga, Latvia

09:00 - 16:00	**COST Event Registration**
09:30 - 11:00	***Session 5 - Advanced Materials for Chemical Sensors*** *Chairperson: Michele Penza, Action Chair - ENEA, Brindisi, Italy*
09:30 - 10:00	**Several Ways to Get More Data in ChemoSensing** *Marcel Bouvet*, Université de Bourgogne, Institut de Chimie Molèculaire, Dijon, France
10:00 - 10:20	**Application of Chemiresistive Polymer Films in Air Quality Control** *Gita Sakale*, *M. Knite, I. Klemenoks, S. Stepina, S. Sergejeva*, Riga Technical University, Latvia
10:20 - 10:40	**Electrochemical Processes to Functionalize Nanostructured Sensitive Layers for NO_2 Gas Sensors** *Elena Dilonardo*[1,2], *M. Penza*[3], *M. Alvisi*[3], *R. Rossi*[3], *C. Di Franco*[4], *L. Torsi*[2], *and N. Cioffi*[2]; [1]DEE, Politecnico di Bari, Bari, Italy; [2]Department of Chemistry, Università degli Studi di Bari, Bari, Italy; [3]ENEA Brindisi, Italy; [4]CNR-IFN Bari, Bari, Italy
10:40 - 11:00	**Gas Sensors and Artificial Olfaction Instruments - Researches and Application at University of Latvia (ISSP UL, Faculty of Medicine)** *Liga Grinberga, Janis Kleperis*, Institute of Solid State Physics, University of Latvia, Riga, Latvia
11:00 - 11:30	**Coffee Break**
11:30 - 13:00	***Session 6 - Sensors and Systems for Air Quality Control*** *Chairperson: Marcel Bouvet*, Université de Bourgogne, Dijon, France
11:30 - 12:00	**Gas Sensors - Fire Detection and Beyond** *Oliver von Sicard*, Siemens AG, Munich, Germany
12:00 - 12:20	**SOI Micro-hotplates Platforms for Humidity Sensing: Follow-up of the Air Quality Intercomparison Joint-Exercise** *Nicolas Andrè, Laurent Francis,* Université Catholique de Louvain, Electrical Engineering Department, ICTEAM Institute, Louvain-la-Neuve, Belgium
12:20 - 12:40	**Expanding the Capabilities of CO_2 LIDAR System with Nonlinear Optical Chalcogenide Crystals** *Wojciech Kuznik*, Czestochowa University of Technology, Czestochowa, Poland
12:40 - 13:00	**Mobile Air Quality Monitoring with Low-Cost Sensors - Piloting Experience in Zagreb** *Dinko Oletic*, University of Zagreb, Faculty of Electrical Engineering and Computing, Zagreb, Croatia
13:00 - 14:30	**Lunch Break**

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14:30 - 16:00 ***Session 7 - Poster Session***
Chairperson: Gita Sakale, Local Organizing Committee Co-Chair and MC LV Member - Riga Technical University, Riga, Latvia

Posters will be presented by Quick Presentations (5-6 minutes, max 5-6 templated slides) by presenters, preferably Early Stage Researchers. Posters are listed by theme and as-received.

MATERIALS, SENSORS, SYSTEMS AND METHODS FOR AIR QUALITY MONITORING

P01 **Characterization of Organic Matter in Marine Aerosols Near Eutrophic Seawater Ecosystem (Rogoznica Lake, Central Dalmatia) during Winter Season**
Ana Cvitesic, Sanja Frka Milosavljeviç, Irena Ciglenecki, Rudjer Boskovic Institute, Zagreb, Croatia

P02 **LIDAR Sensing of Atmospheric Impurities *versus* Passive FTIR Spectroscopy - A Comparison**
Tomasz Imielski, Czestochowa University of Technology, Czestochowa, Poland

P03 **Effects of Particle Indoor Air Pollution Concerning Smoking Habits**
Sandra Vesere, Iveta Steinberga, Faculty of Geography and Earth Sciences, University of Latvia, Riga, Latvia

P04 **Odour Measurements Using Commercial USB-Stick Sensor Devices**
Sanda Palapa, Iveta Steinberga, Faculty of Geography and Earth Sciences, University of Latvia, Riga, Latvia

P05 **Chemiresistive VOC Sensor Materials Based on Silicone Rubber Composites**
Sandra Guzlena, Riga Technical University, Latvia

P06 **Ethylene Vinylacetate Copolymer and Nanographite Particle Composite as VOC Sensor**
Santa Stepina, Riga Technical University, Latvia

P07 **Integration and Performance of an Ultra-Low Power Palladium-based MEMS Hydrogen Sensor for High Selective Monitoring and Fast Detection**
Thomas Walewyns, Nicolas Andrè, Laurent Francis, Université Catholique de Louvain, Electrical Engineering Department, Louvain-la-Neuve, Belgium

P08 **Optical Air Quality Sensors: Benzene, Dust, CO_2**
J. Alnis[1,2], *I. Fescenko*[1], *Z. Gavare*[1], *G. Revalde*[2], *A. Vrublevskis*[2], 1)Institute of Atomic Physics and Spectroscopy, University of Latvia, Latvia; 2)Institute of Technical Physics, Riga Technical University, Latvia

P09 **Gas Sensors Based on PLD-Modified Graphene for Environmental Monitoring**
Margus Kodu, Artjom Berholts, Tauno Kahro, Tea Avarmaa, Ahti Niilisk, Harry Alles, Raivo Jaaniso, Institute of Physics, University of Tartu, Estonia

P10 **Spinel Ferrite Gas Sensors**
Andris Sutka, Institute of Silicate Materials, Riga Technical University, Riga, Latvia

P11 **Practical Application of Commercial Alpha-MOS E-Nose for Air Quality Control in Riga**
Kala Aiga, Oskars Beikulis, Janis Rubinis, Estonian, Latvian & Lithuanian Environment Ltd, Riga, Latvia

P12 **One-dimensional ZnO Nanostructures and Their Optoelectronic Applications**
R. Yatskiv, J. Grym, M. Hamplova O. Cernohorsky, J. Vanis, Synthesis and characterization of nanomaterials, Institute of Photonics and Electronics AVCR, Prague, Czech Republic

P13 **Micro/Nanomechanical Elements Studied by Laser Photoacoustic Spectroscopy for the Development of New Sensing Technologies**
M. Dostál[1,2], *J. Suchánek*[1,2], *T. Vlasáková*[1,3], *P. Janda*[1], *Z. Zelinger*[1]; [1]J. Heyrovský Institute of Physical Chemistry, v.v.i., Academy of Sciences of the Czech Republic, Praha, Czech Republic; [2]*Technical University of Ostrava, Faculty of Safety Engineering, Ostrava, Czech Republic;* [3] Charles University in Prague, Faculty of Science, Prague, Czech Republic

16:00 - 16:30	***Discussion on EU Initiatives related to COST Action TD1105*** *Chairperson: Michele Penza, Action Chair - ENEA, Brindisi, Italy*
Riga Time **16:00 - 16:10**	***Live Video Chat Brussels-Riga - Brussels (CET: -1h EET) and Riga Time (EET: +1h CET)*** **Policy Inputs from DG Research and Innovation on EU Cluster Sensor-Systems** *Hans Hartmann Pedersen*, EC DG R&I Policy Officer, Brussels, Belgium
16:10 - 16:20	**Research & Innovation Priorities of the COST Action TD1105 and EU Cluster Sensor-Systems** *Michele Penza*, ENEA, Brindisi, Italy
16:20 - 16:30	**Discussions from COST Action TD1105 Partners/Stakeholders**
16:30	**Closure of COST Action TD1105 *EuNetAir* WORKSHOP**

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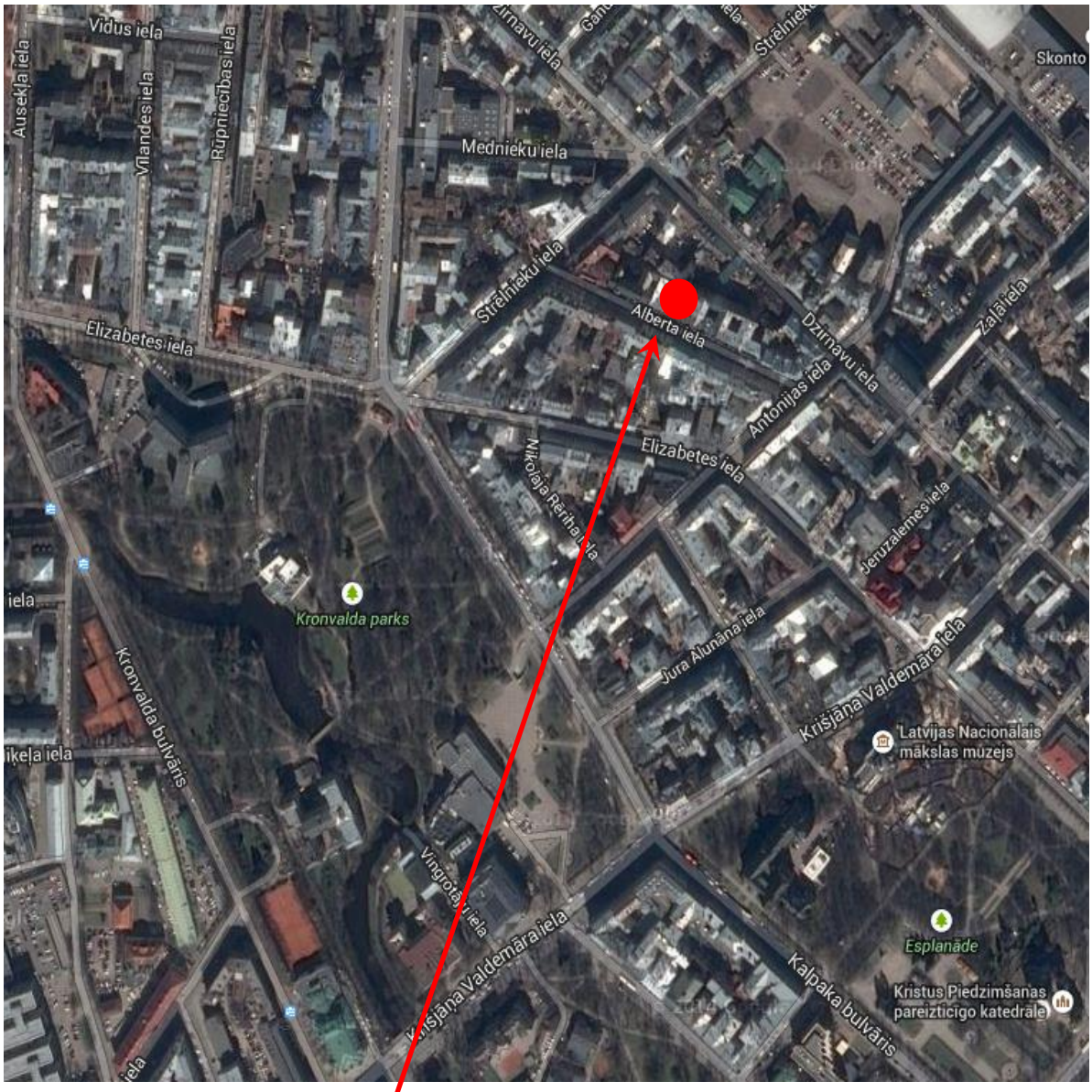
3rd Action Workshop Venue/Location of COST Action TD1105 EuNetAir

THIRD INTERNATIONAL ACTION WORKSHOP on

New Trends and Challenges for Air Quality Control

Riga (Latvia), 26 - 27 March 2015

University of Latvia, Faculty of Geography and Earth Sciences
Alberta Street, 10, LV-1010, Riga, Latvia



Conference Venue: University of Latvia

Faculty of Geography and Earth Sciences

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Welcome from Action Chair

WELCOME ADDRESS

This is a great honor and my pleasure to chair and welcome to ALL PARTICIPANTS of the **THIRD INTERNATIONAL ACTION WORKSHOP** of our COST Action TD1105 *European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability - EuNetAir*.

This COST Workshop - held on 26-27 March 2015 - on ***New Trends and Challenges for Air Quality Control*** is organized by **University of Latvia**, supported by **Riga Technical University** and hosted at *Auditorium of Faculty of Geography and Earth Sciences* of the University of Latvia, with Local Organizing Support from **University of Latvia**, Riga, Latvia.

This **Third International *EuNetAir* Workshop** follows the first one organized at *Barcelona*, Spain (20 June 2013) as Satellite Event inside *Transducers 2013 - Eurosensors XXVII*, and the second one organized at Brindisi, Italy (25-26 March 2014). This **Riga Workshop** is attended from at least 49 Participants and includes 7 Sessions with 2 Keynote Speakers, 4 Invited Speakers, 18 Oral Speakers and 13 Poster Presenters from at least 18 COST Countries. An international Advisory Board (*Steering Committee*) composed by 22 Members has served with S&T inputs to define Workshop Programme. *Female participants* are as 37% and *Male participants* are as 63% with a quota of *Early Stage Researchers* as 37%.

The concerted COST Action TD1105 *EuNetAir* - related to R&D issues of the air quality monitoring including environmental technologies, nanomaterials, functional materials, gas sensors, smart systems, air-pollution modelling, measurements, methods, standards and protocols - is very pleased to connect international specialists and excellent scientists to create a networking of Pan-European R&D platform from 30 COST Countries and 7 Non-COST Countries. Most part of COST Countries are represented in this Meeting.

Special thanks to **COST Officers**: Dr. Deniz Karaca, *ESSEM Science Officer* and Dr. Andrea Tortajada, *Administrative Officer*, involved to manage policy & administration in our Action. Action is indebted to *DG R&I Policy Officer*, Hans Hartmann Pedersen, for *Live Video Chat* planned on meeting second-day to welcome workshop participants and give policy inputs devoted to the *European Sensor Systems Cluster*.

On behalf of the Action Management Committee, I would like to thank **ALL Participants**, **Grant Holder**, **Action Scientific Secretary**, **Local Organizing Committee** by **University of Latvia**, represented by *Chairman of University of Latvia Senate*, and **Riga Technical University**, represented by *Vice-Rector*, and **Riga City Council**, represented by a *Delegate of Riga City Council*, in order to give us the opportunity to disseminate the results of the COST Action TD1105 *EuNetAir* towards a wide international targeted audience involved in the Air Quality Control, with special focus on *Air Quality Control Applications*. With their valuable scientific work and management, kind availability and great enthusiasm will make our Action Workshop very successful !

Enjoy your *EuNetAir* Workshop at *University of Latvia* in Riga !

Brindisi, 11 March 2015

Michele Penza, ENEA, Brindisi, Italy
COST Action TD1105 Chair
michele.penza@enea.it

EuNetAir COST Action TD1105 Logo

LIST OF PRESENTERS

THIRD INTERNATIONAL ACTION WORKSHOP on New Trends and Challenges for Air Quality Control

Welcome Address Session

Welcome: Delegate of Riga City Council
Janis Kleperis, Member of Riga City Council, Latvia

Welcome: University of Latvia
Maris Klavins, Chairman University of Latvia Senate, Riga, Latvia

Welcome: Riga Technical University
Talis Juhna, Vice-Rector for Research, Riga Technical University, Riga, Latvia

Welcome: COST Action TD1105 EuNetAir
Michele Penza, Action Chair, ENEA, Brindisi, Italy

Session 1 - Plenary Session

COST Action TD1105: European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability. Overview and Plans of COST Action TD1105
Michele Penza, Action Chair, ENEA, Brindisi, Italy

Health Effects of Air Pollution in Europe
Michal Krzyzanowski, Former Head WHO European Centre for Environment and Health, Bonn Office, Germany - Honorary Affiliation: Environmental Research Group, King's College London, UK

Session 2 - Environmental Informatics and AQ Sensors

CMOS Sensor Systems for Air Quality Monitoring
Foysol Chowdhury, Action WG Member, CCMOSS Ltd, Cambridge, UK

Preprocessing, Analyzing and Modeling of Air Quality Measurement Data
Kostas Karatzas, Aristotle University of Thessaloniki, Greece

Towards Personal Exposure Estimates Using Low-Cost Air Quality Sensors and Data Fusion Techniques
Philipp Schneider, Action MC Member, NILU, Kjeller, Norway

Air Quality Modelling and Chemical Weather Forecasting at Different Scales
Camillo Silibello, Project manager, ARIANET srl, Milan, Italy

Session 3 - Methods and Applications for Environmental Sustainability

"What Can Be Done When Pollutants Are in the Air ?"
Stanislaw W. Gawronski, Warsaw University of Life Science, Warsaw, Poland

The 1st EuNetAir Air Quality Joint-Exercise Intercomparison: Assessment of Micro-Sensors versus Reference Methods
Carlos Borrego, IDAD and University of Aveiro, Aveiro, Portugal

Air Pollution Modelling for Regulatory Purposes: Riga Case-Study
Iveta Steinberga, Aiva Eindorfa, Oskars Stulbergs, University of Latvia, Riga, Latvia

Making Visible the Invisible: Communicating Air Quality
Nuria Castell-Balaguer, NILU - Norwegian Institute for Air Research, Kjeller, Norway

Session 4 - Modelling and Applications for Air Quality Control

Simulation of European Air Quality by WRF-CMAQ Models Using AQMEII-2 Infrastructure
E. Georgieva, *D. Syrakov*, M. Prodanova, I. Etropolska, K. Slavov, Bulgarian Academy of Sciences, Sofia, Bulgaria

Air Quality Control in Hungary: Recent Changes
Krisztina Labancz, Hungarian Meteorological Service, Budapest, Hungary

On a Multilevel Parametric CFD Model for Urban Air Pollution Modelling
Zoltan Horvath, Department of Mathematics and Computational Sciences, Szechenyi Istvan University, Gyor, Hungary

Review of Ambient Particulate Matter Levels and Source Contribution in Serbia
Milena Jovasevic-Stojanovic[1], Anka Cvetkovic[2], Tihomir Popovic[3]; 1) Action MC Member, Institute Vinca, Belgrade, Serbia; 2) Public Health Institute; 3) Serbian Environmental Protection Agency

The MOSSClone FP7 project: Monitoring Air Quality using Moss as Passive Sensor
José Angel Fernández Escribano, Project Coordinator, Facultad de Biología, Universidade de Santiago de Compostela (USC), Santiago de Compostela, Spain

Kernel Networks for Learning from Sensory Data
Roman Neruda, Vera Kurkova, Institute of Computer Science, Academy of Sciences of the Czech Republic, Prague, Czech Republic

Session 5 - Advanced Materials for Chemical Sensors

Several Ways to Get More Data in ChemoSensing
Marcel Bouvet, Universitè de Bourgogne, Institut de Chimie Molèculaire, Dijon, France

Application of Chemiresistive Polymer Films in Air Quality Control
Gita Sakale, M. Knite, I. Klemenoks, S. Stepina, S. Sergejeva, Riga Technical University, Latvia

Electrochemical Processes to Functionalize Nanostructured Sensitive Layers for NO2 Gas Sensors
Elena Dilonardo[1,2], M. Penza[3], M. Alvisi[3], R. Rossi[3], C. Di Franco[4], L. Torsi[2], and N. Cioffi[2];
[1]DEE, Politecnico di Bari, Bari, Italy; [2]Department of Chemistry, Università degli Studi di Bari, Bari, Italy; [3]ENEA Brindisi, Italy; [4]CNR-IFN Bari, Bari, Italy

Gas Sensors and Artificial Olfaction Instruments - Researches and Application at University of Latvia (ISSP UL, Faculty of Medicine)
Liga Grinberga, Janis Kleperis, Institute of Solid State Physics, University of Latvia, Riga, Latvia

Session 6 - Sensors and Systems for Air Quality Control

Gas Sensors - Fire Detection and Beyond
Oliver von Sicard, Siemens AG, Munich, Germany

SOI Micro-hotplates Platforms for Humidity Sensing: Follow-up of the Air Quality Intercomparison Joint-Exercise
Nicolas Andrè, Laurent Francis, Université Catholique de Louvain, Electrical Engineering Department, ICTEAM Institute, Louvain-la-Neuve, Belgium

Expanding the Capabilities of CO2 LIDAR System with Nonlinear Optical Chalcogenide Crystals
Wojciech Kuznik, Czestochowa University of Technology, Czestochowa, Poland

Mobile Air Quality Monitoring with Low-Cost Sensors - Piloting Experience in Zagreb
Dinko Oletic, University of Zagreb, Faculty of Electrical Engineering and Computing, Zagreb, Croatia

Session 7 - Poster Session
MATERIALS, SENSORS, SYSTEMS AND METHODS FOR AIR QUALITY MONITORING

P01: Characterization of Organic Matter in Marine Aerosols Near Eutrophic Seawater Ecosystem (Rogoznica Lake, Central Dalmatia) during Winter Season
Ana Cvitesic, Sanja Frka Milosavljeviç, Irena Ciglenecki, Rudjer Boskovic Institute, Zagreb, Croatia

P02: LIDAR Sensing of Atmospheric Impurities versus Passive FTIR Spectroscopy - A Comparison
Tomasz Imielski, Czestochowa University of Technology, Czestochowa, Poland

P03: Effects of Particle Indoor Air Pollution Concerning Smoking Habits
Sandra Vesere, Iveta Steinberga, Faculty of Geography and Earth Sciences, University of Latvia, Riga, Latvia

P04: Odour Measurements Using Commercial USB-Stick Sensor Devices
Sanda Palapa, Iveta Steinberga, Faculty of Geography and Earth Sciences, University of Latvia, Riga, Latvia

P05: Chemiresistive VOC Sensor Materials Based on Silicone Rubber Composites
Sandra Guzlena, Riga Technical University, Latvia

P06: Ethylene Vinylacetate Copolymer and Nanographite Particle Composite as VOC Sensor
Santa Stepina, Riga Technical University, Latvia

P07: Integration and Performance of an Ultra-Low Power Palladium-based MEMS Hydrogen Sensor for High Selective Monitoring and Fast Detection
Thomas Walewyns, Nicolas Andrè, Laurent Francis, Université Catholique de Louvain, Electrical Engineering Department, Louvain-la-Neuve, Belgium

P08: Optical Air Quality Sensors: Benzene, Dust, CO_2
J. Alnis[1,2], *I. Fescenko*[1], *Z. Gavare*[1], *G. Revalde*[2], *A. Vrublevskis*[2], 1)Institute of Atomic Physics and Spectroscopy, University of Latvia, Latvia; 2)Institute of Technical Physics, Riga Technical University, Latvia

P09: Gas Sensors Based on PLD-Modified Graphene for Environmental Monitoring

Margus Kodu, Artjom Berholts, Tauno Kahro, Tea Avarmaa, Ahti Niilisk, Harry Alles, Raivo Jaaniso, Institute of Physics, University of Tartu, Estonia

P10: Spinel Ferrite Gas Sensors
Andris Sutka, Institute of Silicate Materials, Riga Technical University, Riga, Latvia

P11: Practical Application of Commercial Alpha-MOS E-Nose for Air Quality Control in Riga
Kala Aiga, Oskars Beikulis, Janis Rubinis, Estonian, Latvian & Lithuanian Environment Ltd, Riga, Latvia

P12: One-dimensional ZnO Nanostructures and Their Optoelectronic Applications
R. Yatskiv, J. Grym, M. Hamplova O. Cernohorsky, J. Vanis, Synthesis and characterization of nanomaterials, Institute of Photonics and Electronics AVCR, Prague, Czech Republic

P13: Micro/Nanomechanical Elements Studied by Laser Photoacoustic Spectroscopy for the Development of New Sensing Technologies
M. Dostál[1,2], *J. Suchánek*[1,2],*T. Vlasáková*[1,3], *P. Janda*[1], *Z. Zelinger*[1]; [1]J. Heyrovský Institute of Physical Chemistry, v.v.i., Academy of Sciences of the Czech Republic, Praha, Czech Republic;
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Discussion on EU Initiatives related to COST Action TD1105

Live Video Chat Brussels-Riga - Brussels (CET: -1h EET) and Riga Time (EET: +1h CET)
Policy Inputs from DG Research and Innovation on EU Cluster Sensor-Systems
Hans Hartmann Pedersen, EC DG R&I Policy Officer, Brussels, Belgium

Research & Innovation Priorities of the COST Action TD1105 and EU Cluster Sensor-Systems
Michele Penza, ENEA, Brindisi, Italy

Discussions from COST Action TD1105 Partners/Stakeholders

ABSTRACTS OF INVITED TALKS

Invited Talk

COST ACTION TD1105 ON NEW SENSING TECHNOLOGIES FOR AIR-POLLUTION CONTROL AND ENVIRONMENTAL SUSTAINABILITY: OVERVIEW AND PLANS OF ACTION

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Abstract
This is a short overview of the COST Action TD1105 *EuNetAir - European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability* - funded in the framework *European Cooperation in the field of Scientific and Technical Research* (COST) during the period 2012-2016.
The main objective of the Concerted Action is to develop new sensing technologies for Air Quality Control at integrated and multidisciplinary scale by coordinated research on nanomaterials, sensor-systems, air-quality modelling and standardised methods for supporting environmental sustainability with a special focus on Small and Medium Enterprises.
This international Networking, coordinated by ENEA (Italy), includes over 80 big institutions and over 180 international experts from 30 COST Countries (EU-zone: *Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Luxembourg, The Former Yugoslav Republic of Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom*) and 7 Non-COST Countries (extra-Europe: *Australia, Canada, China, Morocco, Russia, Ukraine, USA*) to create a S&T critical mass in the environmental issues.
This COST Action [1, 2] (see logo in Fig. 1) will focus on a new detection paradigm based on sensing technologies at low cost for Air Quality Control (AQC) and set up an interdisciplinary top-level coordinated network to define innovative approaches in sensor nanomaterials, gas sensors, devices, wireless sensor-systems, distributed computing, methods, models, standards and protocols for environmental sustainability within the European Research Area (ERA).
The state-of-the-art showed that research on innovative sensing technologies for AQC based on advanced chemical sensors and sensor-systems at low-cost, including functional materials and nanotechnologies for eco-sustainability applications, the outdoor/indoor environment control, olfactometry, air-quality modelling, chemical weather forecasting, and related standardisation methods is performed already at the international level, but still needs serious efforts for coordination to boost new sensing paradigms for research and innovation. Only a close multidisciplinary cooperation will ensure cleaner air in Europe and reduced negative effects on human health for future generations in smart cities, efficient management of green buildings at low CO_2 emissions, and sustainable economic development.

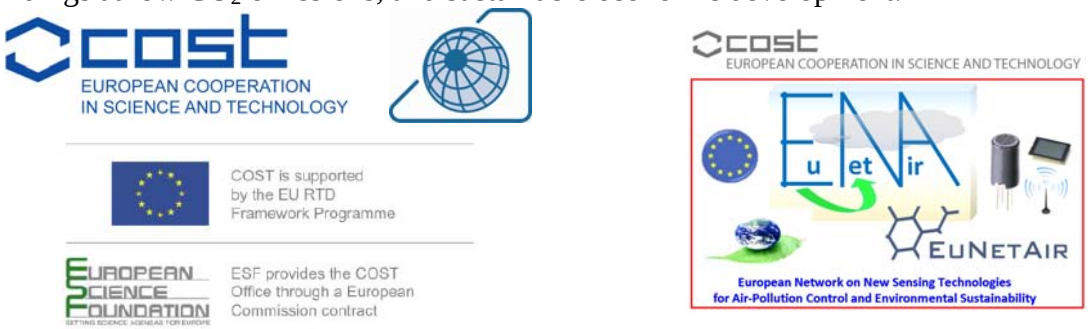

Figure 1. COST Office, ESSEM Domain and Action TD1105 EuNetAir Logo.

Invited Talk

The aim of the Action is to create a cooperative network to explore new sensing technologies for low-cost air-pollution control through field studies and laboratory experiments to transfer the results into preventive real-time control practices and global sustainability for monitoring climate changes and outdoor/indoor energy efficiency. Establishment of such a European network, involving Non-COST key-experts, will enable EU to develop world capabilities in urban sensor technology based on cost-effective nanomaterials and contribute to form a critical mass of researchers suitable for cooperation in science and technology, including training and education, to coordinate outstanding R&D and promote innovation towards industry, and support policy-makers. Main objectives of Action are listed, but not limited to:

- to establish a top-level Pan-European multidisciplinary R&D platform on new sensing paradigm for AQC contributing to sustainable development, green-economy and social welfare
- to create collaborative research teams in the ERA on the new sensing technologies for AQC in an integrated approach to avoid fragmentation of the research efforts
- to train Early Stage Researchers (ESR) and new young scientists in the field for supporting competitiveness of European industry by qualified human potential
- to promote gender balance and involvement of ESR in AQC
- to disseminate R&D results on AQC towards industry community and policy makers as well as general public and high schools.

The Workplan is organized in four complementary Working Groups (WGs), each devoted to a progressive development of synthesis, characterization, fabrication, integration, prototyping, proof-of-concepts, modeling, measurements, methods, standards, tests and application aspects. The four WGs with the specific objectives are:

- **WG1**: *Sensor materials and nanotechnology*
- **WG2**: *Sensors, devices and sensor-systems for AQC*
- **WG3**: *Environmental measurements and air-pollution modeling*
- **WG4**: *Protocols and standardisation methods*

This Action will focus on the study of sensor nanomaterials and nanotechnologies exhibiting unique properties in terms of chemical and thermal stability, high sensitivity, selectivity. Nanosize effects of functional materials will be explored for integration in the gas sensors at low power-consumption. Furthermore, specific nanostructures with tailored sensing properties will be developed for gas sensors and sensor-systems with advanced functionalities.
Selected high-quality research products and innovative technologies developed by the partnership of COST Action TD1105 are shown in the Figure 2.

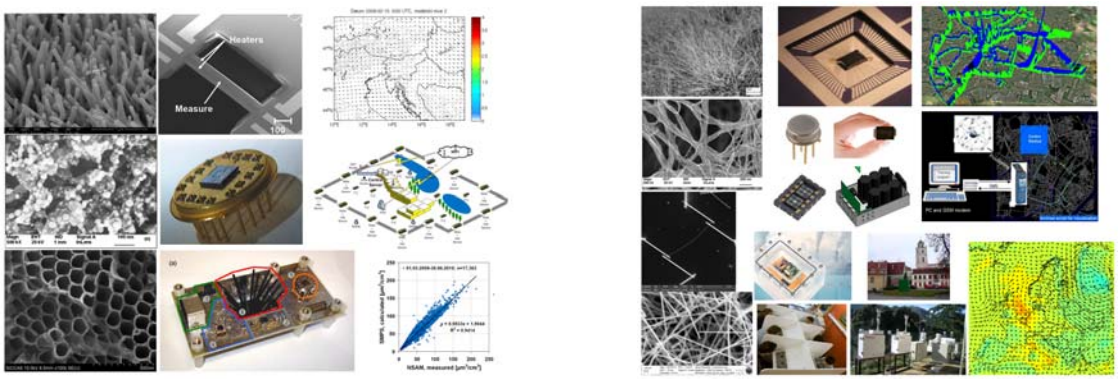

Figure 2. Selected R&D technological products developed by some partners (academia, research institutes, agencies, industry) involved in the COST Action TD1105 *EuNetAir*. Courtesy from *EuNetAir* partnership.

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Invited Talk

HEALTH EFFECTS OF AIR POLLUTION IN EUROPE

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Abstract
Many pollutants present in the outdoor air affect health but the best recognized and widespread health effects are attributed to particulate matter (especially $PM_{2.5}$, particles with less than 2.5 μm aerodynamic diameter), nitrogen dioxide (NO_2) and ozone. Research evidence on risks related to these pollutants is growing constantly in the recent decades. Systematic review of this evidence conducted in 2005 resulted in the most recent update of the World Health Organization´s Air Quality Guidelines (AQG) [1]. More recently, World Health Organization (WHO) completed two projects evaluating newly published research results in support to the European Union´s revision of its policies on air quality [2, 3].
This presentation summarizes the conclusions of the WHO projects and supplements it with the selected results from studies published in the recent two years to provide a synthesis of the current knowledge on health effects of particulate matter, nitrogen dioxide and ozone. To illustrate the significance of indoor air pollution as a health risk, registered mortality and morbidity due to carbon monoxide (CO) poisoning is presented. The use of sensors in exposure and risk assessment is discussed as well.
According to the WHO assessment, the evidence accumulated since 2005 supports and strengthens the conclusion about a causal link between $PM_{2.5}$ and adverse health outcomes in humans, confirming the scientific basis of the 2005 WHO Guidelines. New evidence indicates that health is affected also at concentrations below the AQG levels. Based on a large number of epidemiological, clinical and laboratory studies, a causal link between $PM_{2.5}$ and cardiovascular diseases has been established, and the International Agency for Cancer Research classified particulate matter from outdoor air pollution as “carcinogenic to humans”. New studies show association of adverse birth outcomes and childhood respiratory diseases with exposure to particulate matter.
The Global Burden of Disease (GDB) project classified outdoor air pollution among ten (out of 67) risk factors associated with the highest burden of disease globally [4]. Using the GDB project methodology, WHO estimated that 3.73 million deaths globally could be attributed to outdoor air pollution indicated by $PM_{2.5}$ in 2012 [5]. For Europe, this number amounted to 482 thousand cases.
Intensive research on association of the health effects with specific sources or properties of particulate matter indicates that various (coarse, fine and ultrafine) fractions of PM may play roles in causing the effects. Consistent evidence points to combustion as an important source of health-related PM.
New studies on health effects of NO_2 indicate that this gas may have some direct short- and long-term effects, and be not only an indicator of a combustion-related mixture causing observed health effects. Such effects, including increased mortality associated with long term exposure, have been observed at NO_2 concentrations close, or below, current AQG level.
Besides well recognized association of morbidity and mortality with short term exposures to ozone, recent population studies suggest that long term average of daily maximum ozone concentration may affect long-term respiratory mortality, especially among people with potentially predisposing conditions (chronic obstructive pulmonary disease, diabetes, congestive heart failure and myocardial infarction).

In many parts of the world, household combustion of solid fuels is a source for hazardous air pollution exposures both indoors and outdoors. Global burden of disease due to this pollution (4.3 million deaths in 2012 [6]) exceed that of outdoor air pollution, mostly due to widespread use of solid fuels by households in developing countries of south-east Asia. However, also for Europe ca. 117 thousands premature deaths are estimated to be associated with this source of pollution. The recently published WHO guidelines [7] recommend elimination of stoves polluting indoor air from houses and achievement of indoor air quality compatible with WHO air quality guidelines for PM [1] and CO [8].
Acute effects of CO exposure in Europe include deaths due to CO poisoning (2676 deaths registered in 2012 [9]). Data available from some European countries show that number of hospitalizations due to toxic effects of CO exceeds number of deaths many times.
In summary, the evidence on the health effects of air pollution and on the burden of disease associated with air pollution increased significantly in the last decade. In some of the studies, air quality sensors have been widely used for assessment of exposure (in particular Ogawa badges for studies on NO_2 effects). Sensors are a part of CO detection alarms, directly contributing to prevention of CO poisoning in households. Availability of inexpensive sensors for other health-relevant air pollutants, especially indicating increased PM levels, would greatly benefit risk assessment and management.

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Invited Talk

CMOS SENSOR SYSTEMS FOR AIR QUALITY MONITORING

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Abstract

Metal oxide (MOX) gas sensor concepts were originally introduced by Brattein et al. [1] and Heiland [2] in early 1950's. The application of MOX for gas sensing started to be exploited for commercial market as early as 1957 by Bielanski et al [3] and later capitalised by Seiyama et al [4] in 1962, who later formed Figaro Engineering, in 1971, thus enabling volume production. To this date Figaro remains as one for the leading companies for developing solid state gas sensors in industry, with alumina being the substrate for sensing and heating platform. In the same 1960's time frame with the advent MOSFET, MEMS and subsequent development of CMOS in 1963 initiated with patent by Frank Wanlass, a new dimension in sensors emerged for more innovative miniature sensors as an integral part integrated electronic components [5]. This development enabled a formation of a new generation companies such as Sensirion, Micronas, Cambridge CMOS Sensors, SGX and others, to capitalise on CMOS as a platform for air quality monitoring (AQM) gas sensors, as well as Figaro who in 2014, announced MEMS sensor. However, challenge of MOX and FET-based sensors for sensitivity, selectivity and stability still remains for high volume production of miniature gas sensors. Using CMOS sensor systems approach with integrated on-chip circuits and sensor arrays, together with algorithmic signal processing solutions, these problems are beginning to be resolved as the technology is being promoted for smartphone and wearable devices. The sensor array concept was first was proposed by Persaud and Dodd in the early 1980s [6], where cluster of non-selective sensors was suggested to be used to discriminate between simple odours through pattern recognition schemes. Furthermore, first use of SOI-CMOS technology in the design of a chemo-resistive gas sensor was proposed by Gardner and Udrea [7], and this platform SOI process is now being used for enabling beyond CMOS, FinFET and TFET devices, thus future prospects exists for even more innovations to be made to enable nano-geometry, ultra-low voltage, low powers sensors for AQM applications as well. In this presentation we will categorise the types of CMOS gas sensors that are available and compare their performance with state-of-the-art AQM systems [8]. Furthermore, we present some key parameters of CMOS sensor systems and highlight some of the key problems with CMOS-based sensors and show how some these issues are being resolved by algorithmic and array-based sensing approaches [9, 10]. We will also look at future trends and prospects for emerging MOSFET and TFET gas sensor [11] leading to room temperature sensing application aimed at ultra-low power mobile phone and internet of things applications [12].

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Oral Presentation

PREPROCESSING, ANALYZING AND MODELING OF AIR QUALITY MEASUREMENT DATA

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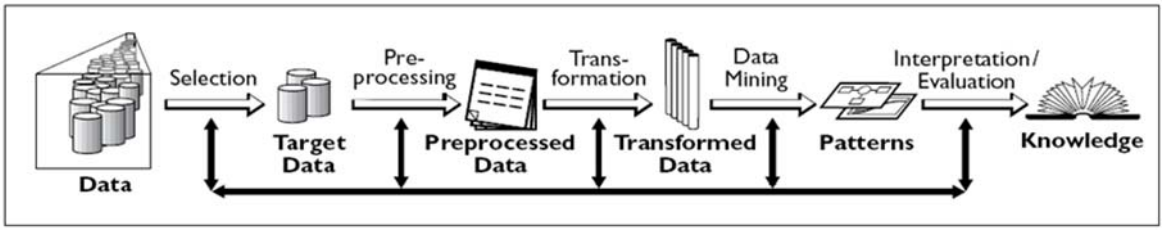
Introduction

Air quality management (AQM) calls for (a) the assessment of air pollution in the area of interest (mainly with the aid of monitoring data), (b) the modelling of the air quality system at hand, and (c) the forecasting of its behaviour and status (concentration levels). This is a problem that requires sufficient knowledge of the scientific domain of interest, and advanced capabilities for the identification and forecasting of key parameters affecting decision making. On this basis, it is essential to formulate and apply methodologies that allow for knowledge extraction, as well as critical parameter forecasting (i.e. concentration levels of pollutants), on the basis of available data and information, in an operational environment. For these reasons, a number of computational methods have been employed in an effort to model and simulate AQ during the last decades. These methods included deterministic modelling, as well as the application of various mathematical methods and tools from the area of Computational Intelligence.

AQ data processing chain



Fayyad et al. 1996, 'The KDD process for extracting useful knowledge from volumes of data', Communication of the ACM, 39 (11), 27-34

Data coming from the operation of various types of AQ monitoring instruments are heterogeneous in terms of "production" methodology and technology, quality, completeness, and comparability. For this reason an AQ processing chain needs to be followed in order to pre-process, analyse and model the relevant AQ system.

In this presentation we are going to address all AQ data processing steps, and discuss methods suitable for each one of the processing phases. An indicative list of methods and tasks follow:

Preprocessing:

- Identification of missing data and outliers
- Calculation of descriptive statistics
- Other

Analysis:

- Data presentation and visual inspection: Basic graphs
- Periodicity identification
- Trend analysis, de-trenting
- Data normalization
- Correlation analysis
- Dimensionality reduction
- Clustering

Modelling:

- Data-oriented modelling
- Missing data reconstruction
- Forecasting of parameters of interest

Knowledge: Quality of Life service design & development

- Personalised QoL information services design
- Participatory sensing/crowdsourcing data usage

Selected related publications

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Oral Presentation

TOWARDS PERSONAL EXPOSURE ESTIMATES USING LOW-COST AIR QUALITY SENSORS AND DATA FUSION TECHNIQUES

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Abstract

Low-cost air quality sensors have significant potential for providing estimates of personal exposure to air pollutants. Quantifying exposure to pollutants in a personalized way is helpful for a wide variety of applications related to outdoor activities in urban environments, including but not limited to 1) finding the least polluted route and thus minimizing one's exposure 2) identifying the best time for outdoor exercise for a given track 3) estimating the personal inhaled dose of one or multiple air pollutants over a given path. We discuss two different approaches in which low-cost microsensors for air quality can be used towards providing personal exposure and dose estimates along a user-specified path in an urban environment:

> **Approach 1**: Direct exposure estimation using low-cost air quality sensors carried along a path by a subject
> **Approach 2**: Indirect exposure estimation by integrating over a user-specified path with the concentration information derived from real-time air quality maps produced by data fusion techniques using low-cost air quality sensors and model information

Approach 1 is based on a subject carrying a low-cost air quality sensor while moving through the environment, for example on foot or by bicycle [1]. By continuously measuring the concentrations that this person is subjected to, their exposure can be quantified along the path at high temporal frequency. Subsequently average exposure and dose as a function of activity can be estimated.

We focus here primarily on **Approach 2**. This technique is indirect in the sense that the data from the air quality sensors is used for generating near real-time high-resolution air quality maps using data fusion techniques. These maps are then used to calculate the personal exposure along a user-specified path. This path could be derived for example from a GPS device or smartphone for a recently used track or from online routing services such as Google Maps for a planned track. This approach has significant advantages over approach 1 in that it is more versatile. Exposure estimates can be obtained over any conceivable route and it further allows travel planning for routes within the mapping domain based on the expected exposure and dose. The data fusion approach applied here uses the output from a local air dispersion model (e.g., EPISODE, see [2]) as basemaps and subsequently fuses them using geostatistical techniques with real-time observations from a low-cost sensor network deployed throughout a city. Data fusion techniques (as a subset of data assimilation) allow for combining observations with model data and therefore provide a means of adding value to both the observations by filling spatio-temporal gaps in the data and the model by constraining it with the observations [3]. As such, data fusion of observations from high-density low-cost sensor networks together with air quality models can contribute to improving urban-scale air quality mapping. The underlying methodology for the data fusion approach is

based on residual kriging and includes a fully automated system for establishing a relationship between the downscaled model output and the observations, estimating the spatial autocorrelation function from the observations, performing kriging of residuals, and producing the final map as a combination of a regressed map and kriged residuals. Figure 1 shows an example of using data fusion techniques for deriving exposure estimates along a given track in an urban environment.

We present examples from both approaches, with Approach 1 focusing on particular matter (PM) observations using a *DustTrak* instrument and black carbon measurements using a *MicroAethalometer* in Oslo. Examples for Approach 2 primarily target nitrogen dioxide and PM.

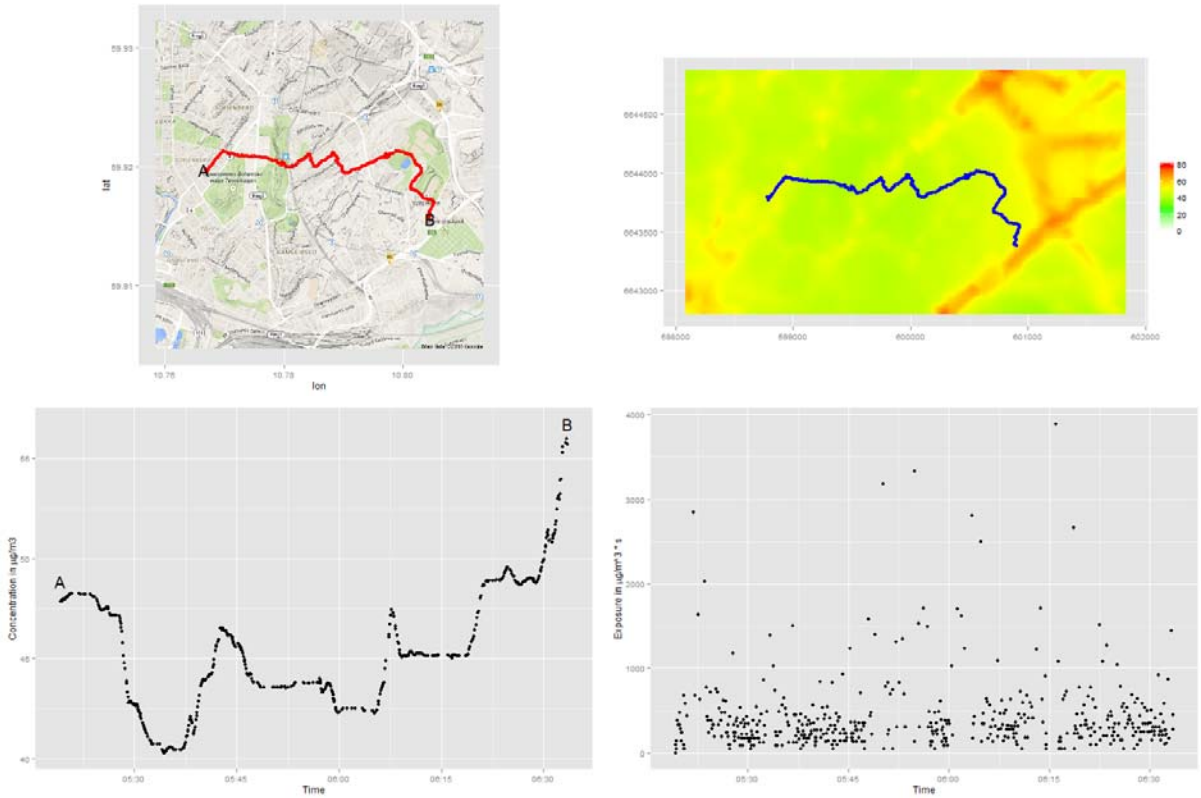

Figure 1: *Example of extracting exposure information along a track in an urban environment (here Oslo, Norway) using information from low-cost air quality sensors and models. The top left panel shows the geographical context of the path, the top right panel shows a map of the average NO_2 concentrations in the area derived from data fusion techniques, the bottom left panel shows the NO_2 concentrations extracted along the user-specified path from the fused map, and the bottom right panel shows the estimated exposure along the path, which can be used to estimate inhaled dose.*

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Oral Presentation

AIR-QUALITY MODELLING AND CHEMICAL WEATHER FORECASTING AT DIFFERENT SCALES

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Abstract

A more realistic representation of the spatial distribution of pollutants is the final goal of "data fusion" (DF) methods, that combine information from air quality monitoring networks with other sources such as reanalysis data, satellite data, and data sets obtained from statistical models or Air Quality Models (AQMs). Data assimilation (DA) can be defined as a subset of DF in which AQMs are one of the sources of data to produce an optimal representation of the state of the atmosphere. DA methods are used to overcome the limitations of AQMs and of the simple interpolation of observations by combining available information in a coherent way (Figure 1).

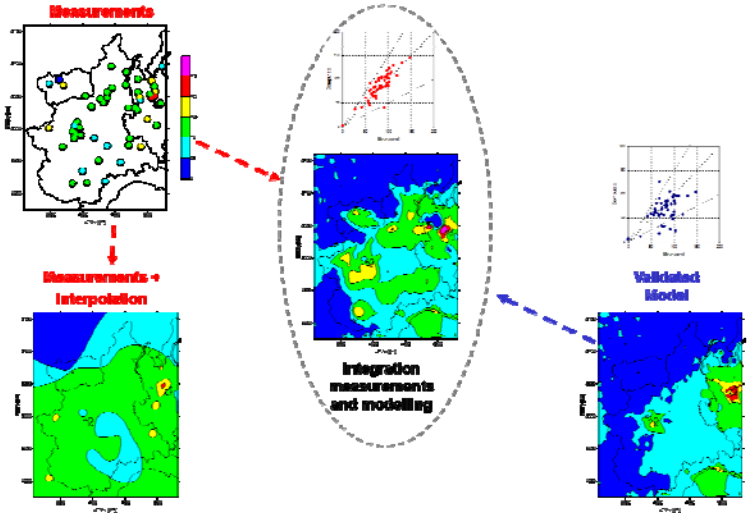

Figure 1. Integration of measurements and observations.

To support local and national environmental agencies in their activities related to air quality assessment and management, ARIANET S.r.l. and Aria Technologies S.A. have developed different modelling systems, allowing to investigate the processes affecting the air quality from the local to the regional scale. As relevant examples, those models are the core constituents of the atmospheric component of the "National Integrated Modelling system for International Negotiation on atmospheric pollution" (*MINNI*, http://www.minni.org/) and the Air Quality Forecast System (AQFS) "*QualeAria*" (developed within the EU funded research project FUMAPEX and the COST Action ES0602 collaboration framework). *QualeAria* provides air quality forecasts for current day and next 120 hours over the entire Italian peninsula (http://www.aria-net.it/qualearia/index_en.html) and produces boundary conditions for other operational regional AQFS. These modelling systems are also used by several Italian Regional Environmental Protection Agency (ARPA) to assess and manage air quality across their territories (see Figure 2), to produce Near Real Time (NRT) air quality maps (see the system implemented by ARPA Lombardia - Northern Italy: http://www2.arpalombardia.it/sites/QAria/_layouts/15/QAria/IModelli.aspx) and to provide air quality forecasts (see the system implemented by ARPA Lazio - Central Italy: http://www.arpalazio.net/main/aria/sci/previsioni/o3.php?region=roma). AQMs have proved to be capable to reproduce regional and urban atmospheric pollution phenomena and their reliability has been demonstrated by several modelling evaluation studies despite the many sources of uncertainty on input information (emission, meteorology) and incomplete representation of the physical/chemical phenomena within the model itself.

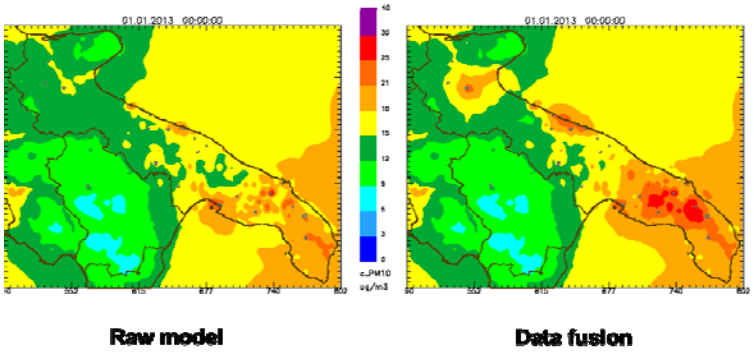

Figure 2. Yearly (2013) PM_{10} concentration field over Puglia region (Southern Italy) produced by an AQM (raw model) and by data fusion methods.

These uncertainties can determine systematic errors in predictions that can be removed by automatic post-processing methods. An example is given by the Kalman filter (KF) that uses the recent past observations and forecasts to estimate the model bias in the future forecast at monitoring locations (Figure 3 shows an example of the results obtained by the application of KF in the ARPA Lazio AQFS).

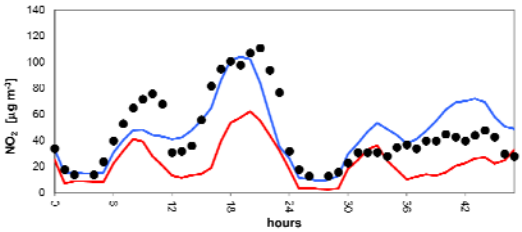

Figure 3. Use of KF (blue line) to improve raw model (red line) 48-hr NO2 forecast at an urban background site in Rome.

At more local scales it becomes relevant to take into account the effect of obstacles on flow, turbulence, and consequently on the dispersion of pollutants. To face these issues, ARIANET S.r.l. and Aria Technologies S.A. developed a 3D modelling systems based on a mass consistent diagnostic wind model coupled with a Lagrangian particle dispersion model. This system permits to simulate the atmospheric pollution at any point even for a very big city (http://www.aria.fr/projets/aircity/index.php?lang=en). Figure 4 shows some results obtained by the application of such a system to evaluate the effects on air quality of innovative architectural and urban solutions (energy efficiency, local traffic management and use of green spaces) adopted in the "CityLife" residential district under development in the city of Milan (Northern Italy). The results of DA techniques enhance the potential of new low cost environmental sensors: deployed in large number throughout the studied area (region, city, district), and possibly monitoring a wide range of pollutants, they could effectively integrated with air quality models results to provide more complete and realistic representation of the actual pollutants distribution in complex environments.

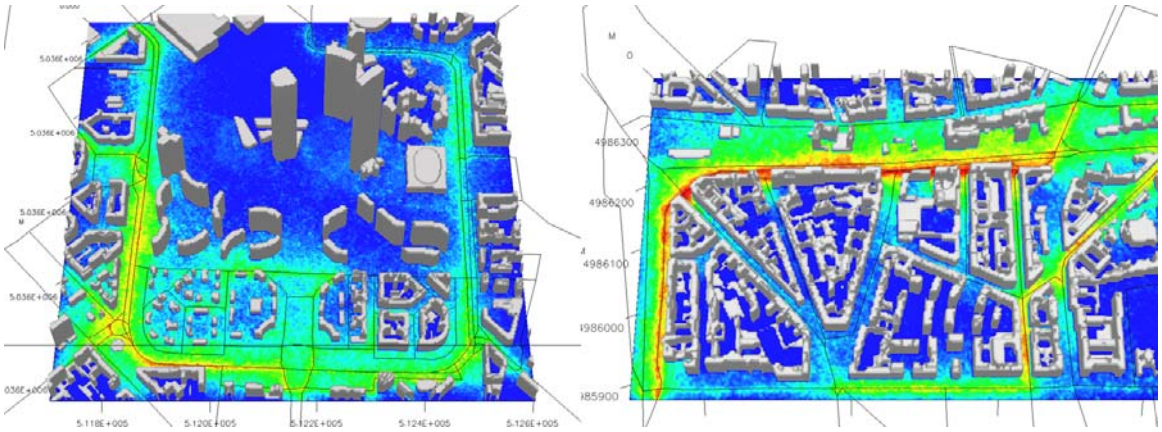

Figure 4. Comparison of NOx ground level concentrations at 2m horizontal resolution due to the local traffic in the new CityLife district (left) and in a reference district (right).

Invited Talk

WHAT CAN BE DONE WHEN POLLUTANTS ARE IN THE AIR

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Abstract

Transportation, industry and household emit various pollutants to the air including particulate matters (PM) - nowadays number one harmful, air pollutant. PM toxicity is magnified when they carry heavy metals (HM), polycyclic aromatic hydrocarbons (PAH) and environmentally persistent free radicals (EPFR). Air as very mobile component of environment is most challenging to be cleaned. If pollutants are emitted to the atmosphere, the only option to remove them in controlled by man manner is phytoremediation - environmental biotechnology in which plants are employed to capture impurities. Plants as a sessile organism are relatively high tolerant to pollution, which together with surface, few times larger than surface occupied for their growth became useful for phytoremediation. Working hypothesis of our study was: as for many other traits we expect that there are significant genotypic inter- and intra-species differences in plant usefulness for phytoremediation. Over 60 trees, shrubs and grass species, recommended for urban areas, were evaluated in our Lab for ability of PM accumulation in 3-4 years study.

Mass of PM and epicuticular waxes were determined gravimetrically. The PM was determined in two categories; surface PM (sPM) and phytostabilised in wax (wPM) and in three size fractions (10–100, 2.5–10, and 0.2–2.5 μm) according to method elaborated in our Lab and described by (Dzierżanowski et al 2011, Popek et al 2013).

Great differences exist between examined species in their ability to accumulate PM (up to 10 times). Out of all size fractions in highest amount were large and in lowest were fine PM.

Out of total slightly more than half of PM was sPM (washed with water so this part is probably also easy to be removed by rain and wind). Species of hairy and rough leaves accumulate more coarse PM but those having only wax accumulate more PM of fine fraction and this part as more tightly bound to leaves is for longer time phytostistabilised. Although great differences were recorded between species in amount of wax deposited on leaves no correlation were found between mass of PM and wax.

Trees and shrubs species that belong to *Oleaceae* family are characterized by greater usefulness for PM phytoremediation. Cultivation of plants besides of their esthetical and landscape architecture values, providing oxygen, elimination of heat island if possess high phytoremediation potential may play also a role of green liver to urban inhabitant.

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Oral Presentation

THE 1ST EUNETAIR AIR QUALITY JOINT-EXERCISE INTERCOMPARISON: ASSESSMENT OF MICRO-SENSORS VERSUS REFERENCE METHODS

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Abstract

This work presents a preliminary performance evaluation and assessment of different environmental gas/particulate matter micro-sensors versus standardized air quality referenced methods through the 1st EuNetAir Air Quality Joint-Exercise Intercomparison. This experimental urban air quality monitoring campaign was organized by IDAD - Institute of Environment and Development in Aveiro, Portugal, on 13-27 October 2014 in the scope of COST Action TD1105 - *EuNetAir*.

The two-week experimental campaign was conducted in an urban traffic location in Aveiro city centre counting with 15 teams from research centres, universities and companies coming from 12 COST Countries. The micro-sensors systems were installed side-by-side at IDAD Air Quality Mobile Laboratory that was equipped with standardized equipment and referenced analysers of the following variables: CO (nondispersive infrared spectroscopy), NO_x (chemiluminescence), O_3 (ultraviolet photometry), SO_2 (ultraviolet fluorescence), PM_{10} and $PM_{2.5}$ (Beta-ray absorption method), BTEX (gas chromatography), temperature, humidity, wind velocity/direction, solar radiation, precipitation.

The analysis of the data obtained during the campaign shows that there weren't recorded any exceedances to the limit values for CO, NO_2, O_3, SO_2 or benzene. However, over the two-week campaign, the PM_{10} daily limit of 50 µg/m^3, for the protection of human health, was exceeded 6 times from the 20th to the 25th of October. This was due to the associated traffic emissions and meteorological conditions and also to the simultaneous occurrence of natural events with the transport of particles from North Africa, from the 18th to 31st of October [1]. It's also noticeable that in the first week of the experimental campaign it was observed long periods of precipitation (total of 75.4 mm), high relative humidity (average: 79%, range: 44-90%) and strong wind (average: 2.2 m/s, range: 0.1-5.6 m/s) however in the second week the meteorological conditions changed with no periods of precipitation, high temperatures (average: 21°C, range: 15-30°C), lower relative humidity (average: 65%, range: 39-87%) and wind velocities (average 0.6 m/s, range: 0.1-1.5 m/s).

In this preliminary assessment, from a total of 15 teams that participated in the campaign only 7 teams results were analysed. Therefore a preliminary statistical analysis of field results was conducted allowing a performance evaluation of several micro-sensors, namely Metal Oxide Semiconductor sensors (MOS), Electrochemical sensors and Optical Particle Counter sensors (OPC). Figure 1 presents an example of correlations between data from micro-sensors and reference analysers versus data collection efficiency for different pollutants (NO_2, CO, O_3, $PM_{2.5}$ and PM_{10}).

Oral Presentation

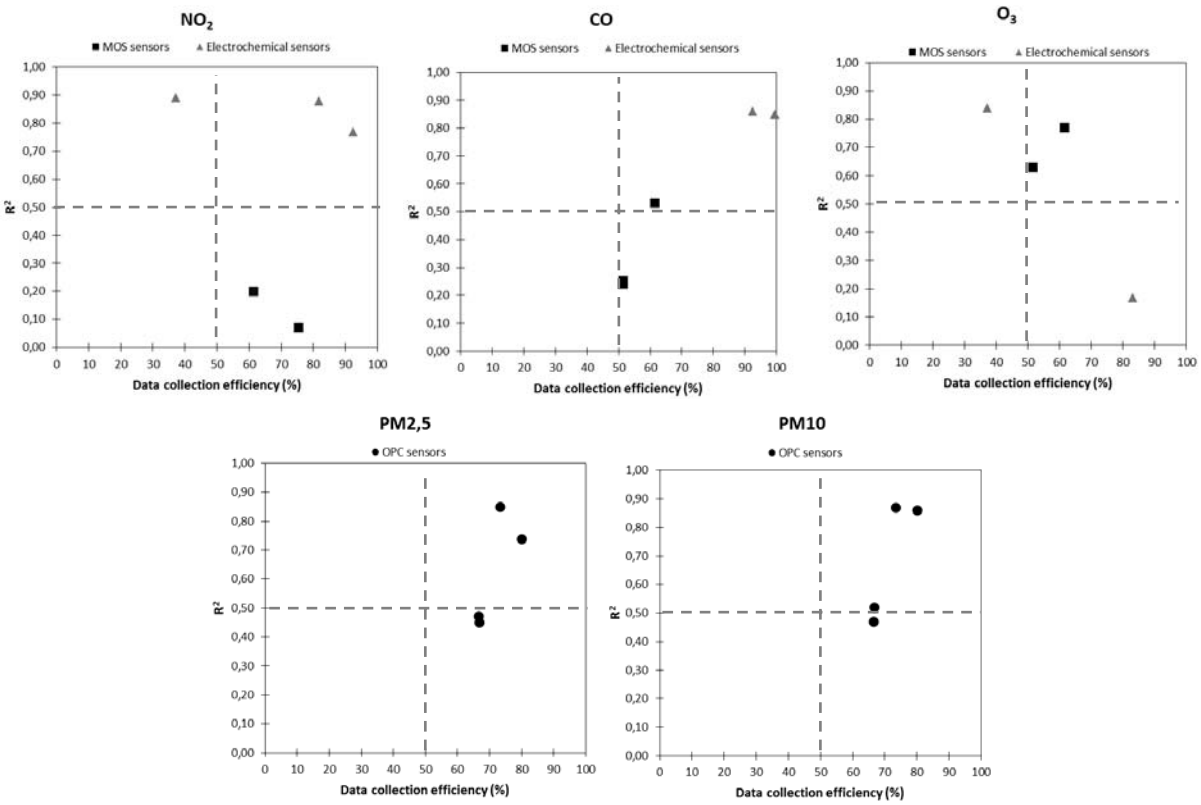

Figure 1. Correlation between micro-sensors and reference analysers vs. data collection efficiency.

Ideally micro-sensors should have strong correlations and high data collection efficiency throughout the entire duration of the campaign, meaning that they should be represented in the second quarter of the graphs area. However, generally some problems were identified in the data collection efficiency of the sensors that may be related to the high relative humidity and temperatures during the campaign, intermittent communication failures and also the instability and reactivity caused by interfering gases.

The analysis shows that for NO_2 and CO measurements performed with electrochemical and MOS sensors a greater correlation with the reference method and a higher efficiency collecting data is noticed for electrochemical sensors. Although for O_3 is observed a greater correlation with the reference method and a higher efficiency collecting data for MOS sensors. The OPC sensors for PM_{10} and $PM_{2.5}$ present correlations that vary between 0.45-0.87 and data collection efficiencies in the range of 67-80%.

The interference of meteorological parameters in micro-sensors measurements, namely Temperature, Relative and Absolute Humidity is analysed in Figure 2 through two examples of correlations for hourly concentration data of O_3 and CO MOS micro-sensors from one selected team.

The O_3 MOS micro-sensor exhibited a good degree of linearity between hourly concentration and Temperature ($R^2 = 0.5774$) as well as with Relative Humidity ($R^2 = 0.5774$). However the correlation concerning Absolute Humidity showed a poor degree of linearity ($R^2 = 0.0048$).

Moreover CO MOS micro-sensor demonstrated a weak correlation between hourly concentration and Temperature ($R^2 = 0.0884$) but acceptable degrees of linearity with Relative ($R^2 = 0.3429$) and Absolute Humidity ($R^2 = 0.2752$).

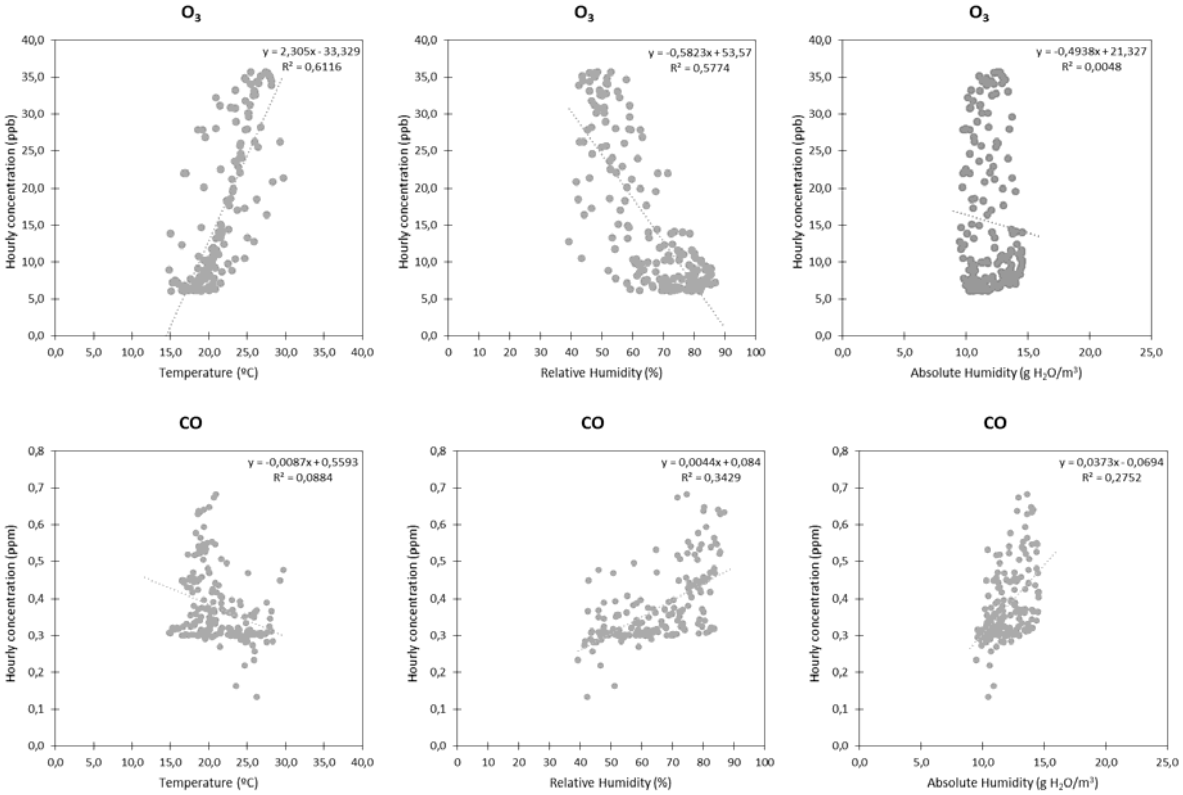

Figure 2. Correlation between hourly concentration data from micro-sensors vs. meteorological parameters.

These results confirm the need to include Temperature and Humidity corrections in micro-sensors data conversion equations. It is also important to analyse and include the sensitivity of the sensors to gaseous interfering compounds to allow a more accurate determination of pollutants concentration.

The utilisation of micro-sensors is still not mentioned for regulatory purposes in European legislation, nevertheless the real-time collected data combined with standardized monitoring have an enormous potential to be applied in new strategies for air quality control, rapid mapping of air pollution over small areas, validation of atmospheric dispersion models or evaluation of population exposure.

Although there is a significant research and development of low-cost sensors for pollutant monitoring, data treatment of sensor signals from field campaigns remains limited and challenging. The preliminary evaluation of the 1st EuNetAir campaign results shows that micro-sensors can be a promising technique for air quality monitoring but it is still necessary to stablish an evaluation protocol approaching issues as sensitivity, selectivity (known interference), short and long term stability, model equation and data validation [2].

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Oral Presentation

AIR POLLUTION MODELLING FOR REGULATORY PURPOSES: RIGA CASE-STUDY

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Abstract
Air pollution problems traditionally are managed by national instruments (legislation, monitoring, air quality action and improvement plans) or by international agreements which varies depending on problem scale in association with particular sources. Classically most dramatic air pollution problems raised at the local scale and close to the particular sources, what could be either mobile (line) or stationary (point). Almost in all European countries air quality models are used for regulatory purposes - issuing emission permits, cases studies for environmental impact assessment, analysis of future development and planning. A various different models are used – Gaussian, Eulerian, empiric, with changing temporal and spatial scale, they could be component dependent as well, but usually air quality models working with primary pollutants included in Air quality directive and Daughter directives. Directive 2008/50/EC (into force from 11 June 2008) regulate that air quality status should be maintained where it is good and improved if necessary. According to more than 10 years' experience of monitoring, Riga (capital of Latvia) municipality should work on air quality improvement actions for nitrogen dioxide (NO_2) and particulate matter (PM_{10}) pollution level decreasing. One of the actions showing roadmap for air quality improvement consist of revision of emission data and sources data base, and further modelling in order to identify hot spots for further actions.

In this study Gaussian plume model is used for air quality zoning to elaborate further restrictions for specific activities which are conducted with air pollution. While NO_2 zoning was developed already 3rd time, PM_{10} zoning maps were created first time. NO_2 zoning results show street canyon dependent concentration distribution in central part of the city showing small progress concerning previous actions in order to decrease air pollution levels. In previous action plans several activities were enforced - restrictions for heavy traffic movement in central part, new pollution sources, public traffic system improvements, mitigation for emission free traffic. PM_{10} zoning was mapped in 3 zones:

(1) yearly average concentration exceeds allowed limit value of 40 µg/m^3;
(2) yearly average concentration is between 30 to 40 µg/m^3;
(3) yearly average concentration is below 30 µg/m^3.

PM_{10} pollution structure is more diverse because of source and processes variety - primary and secondary aerosols; exhaust and non-exhaust emissions. According to zoning results main contributor to PM_{10} pollution is traffic, other pollution sources are less important (see Table 1).

Table 1. Particulate matter PM_{10} source apportionment modelling results in Riga.

No	Sector	Number of sources	Total amount of emissions, t/year	Maximum concentration, $\mu g/m^3$
1	Stationary point sources	454	241.0	17.5
2	Stationary area sources	115	2.3	26.4
3	Traffic	381	31.8	48.7
4	Households	245000	5.2	21.3
5	Background pollution	-	-	

According to detailed traffic source analysis 30-40 % of PM_{10} coming from re-suspension processes, 1-2 % from abrasion processes and left as exhaust aerosols. Modelling results showed highest concentrations in relation to traffic impact and in Riga Sea Port territory where activities are conducted to coal handling and processing.

Oral Presentation

MAKING VISIBLE THE INVISIBLE: COMMUNICATING AIR QUALITY

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Abstract

Clean air is a basic requirement for human health and well-being. However, air pollution continues to pose a significant threat to health worldwide. In Europe, according to the WHO 40 million people in the 115 largest cities in the European Union have exposure to air exceeding WHO air quality guideline values for at least one pollutant [1]. Children living near roads with heavy-duty vehicle traffic have larger risk of respiratory problems as those living near less congested streets [2].

The general public and, in particular, sensitive groups are exposed to air pollution levels that can be harmful for their health. Reducing the personal exposure to air pollution will decrease the likelihood of experiencing health problems associated with air pollution and lower the number of air pollution-related deaths. However, it is necessary that the public understands what the air quality information is telling them. For instance, what does information that air quality "is poor" mean and how can the user act upon this information?

Because low-cost sensors are affordable, small and easy to use by the general public, they offer the opportunity to both monitor air quality at higher spatial resolution than hitherto and provide better estimates of personal exposure as they can be worn by a person during their regular daily routine. Low-cost sensors provide the opportunity to offer to the public personalized and customized information [3].

The challenge is to transform the data gathered by the low-cost sensors into information that is useful and easy to understand by the general public. This is key to increase citizens' awareness of their environment, and enhance their ability to recognize and change their exposure to air pollution.

The EU-funded project Citi-Sense-MOB will address this challenge by providing the general public the possibility of getting personalized air quality information on a mobile phone. The user will be able to check the air quality in their immediate surroundings, select less polluted routes to walk or cycle, and track their individual exposure while moving in the city [4].

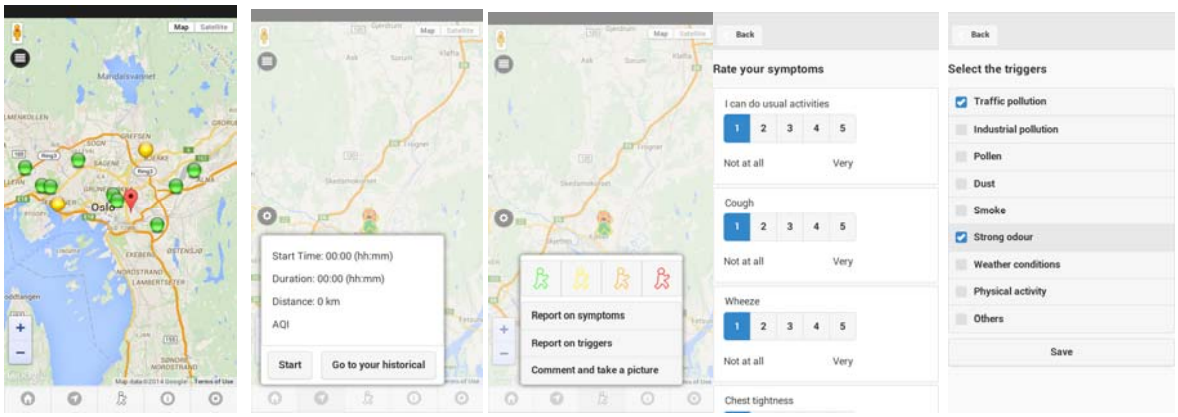
In Citi-Sense-MOB we will also involve citizens as sensors. Citizens will be able to report if they are experiencing any adverse health symptoms and the possible triggers. Citizens will be able to report by using their mobile phone and answering a short questionnaire. The data will be geo-located and stored in a database with the possibility of being visualized in a map as other sensor data.

In order for users to easily visualize the information on air quality, a mobile phone application named Personalized air quality map (PAQ MAP) has been developed. It will be provided as a free download application. PAQ MAP has five main options that are displayed at the bottom of the screen (see Figure 1), which are: "air quality", "tracking", "symptoms", "information"

and “settings”. In the first menu the user can select different display options: the AQI from the sensors and the reference stations, the pollen index, the air quality map and the VGI information (Figure 1a). In the second menu the user can track his/her position and see in near-real-time the data of the sensor being carried (Figure 1b). It is also possible to track the position without carrying a sensor; in that case the data from the air quality map will be showed. The tracks can be stored and shared using social networks. In the third menu the user can report their overall feeling by simply clicking on an icon (Figure 1d), report on specific adverse health symptoms and symptom severity (Figure 1d) and on possible triggers (Figure 1e).

The *Citi-Sense-MOB* project represents an innovative development in environmental monitoring and individual exposure assessment. We are investigating how data from low-cost sensors can contribute to a more comprehensive understanding of air quality and contribute to create maps at road level that complement the data from existing monitoring networks.

The mobile phone application developed within the project will contribute to engage citizens in collecting and sharing environmental data generated by low-cost air quality sensors, and in reporting their individual perception.



(a) **(b)** **(c)** **(d)** **(e)**

Figure 1. Citi-Sense-MOB PAQ MAP mobile phone application to visualize air pollution.

Acknowledgement

Citi-Sense-MOB (http://www.citi-sense-mob.eu) is a collaborative project partly funded by The European Mobile and Mobility Industries Alliance (EMMIA) strand II: Large-scale demonstrators in support of GMES and GNSS based services. We would like to thank to the support from Oslo Kommune, Ruter AS and Nobina AS.

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Oral Presentation

PERFORMANCE OF BULGARIAN WRF-CMAQ MODELING SYSTEM

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Introduction

The purpose of this study is to evaluate the performance of Bulgarian Chemical Weather Forecast System (CWFS) using surface data from the national air quality monitoring network for the year 2013 and focusing on mean daily PM_{10}, 8-hour mean maximum daily O_3 and hourly NO_2 concentrations. The tool for this analysis is the software package "DELTA", developed in the framework of the EU initiative FAIRMODE [1] that considers observation uncertainty in model performance indicators [2]. Although the system was not intended to air quality assessment in the frame of the EU Air Quality Directive (AQD), an attempt is done to obtain insight into the main shortcomings of CWFS related to the air quality in Bulgaria.

Modelling system

Bulgarian CWFS [3, 4] is developed lately and is presented at several EuNetAir events. The forecast period is 3 days starting at 00 UTC each day and the forecast regions are 5: Europe, Balkan Peninsula, Bulgaria, Sofia Region and Sofia City. The nesting approach is used increasing the space resolution from 81 km (Europe) to 1 km (Sofia City). The forecasted pollutants are SO_2, NO_2, Ozone and PM_{10}. The System is based on the well known models WRF (Meso-meteorological Model) and the US EPA dispersion model CMAQ (Chemical Transport Model). The WRF model is driven by the US NCEP Global Forecast System data (1°×1° space and 6 h time resolution). As emission input the TNO data are used for the two biggest domains. For the 3 Bulgarian domains the current emission inventory provided by Bulgarian environmental authorities is exploited. Only results for Bulgaria region (9 km resolution) are used in this study.

Monitoring data

Data from the national air quality monitoring network, maintained by the Bulgarian Executive Environment Agency with the Ministry of Environment and Water, are used in this study. For 2013 observations from 33 stations were available. The number of stations per pollutant is shown in Table 1.

Table 1. Number of stations and data availability (%) for 2013

	NO_2	**O_3**	**PM_{10}**
Number of all stations with measurements	26	22	31
Number of background stations with measurements	21	17	23
Number of valid background stations (more than 75 % of data)	18	16	18

The stations are mostly located in urban areas. Only background stations have been selected for the study. There are only two rural stations both of them in mountain regions.

Results and discussion

In this abstract, only model performance for maximum daily 8-hour mean ozone (8hDMax) will be presented. Figure 2 gives an overview of model performance during the whole year (left) and for the summer period (right). From the available 33 stations only 16 have sufficient data; they are represented with different symbols where colours indicate the region of the station. In general, the model overestimates observations in all regions on annual basis (positive bias), and has problems with correlation, so that only 31% fulfil the DELTA model quality objective (DMQO). Two of the stations in the green area are rural mountain sites.

During summer the model fulfils the criteria at all stations but problems with standard deviation (lack of amplitude) are evident for stations in Sofia and western Bulgaria, while deficit in correlation is noticed mainly at stations from the east-southeast part of the country.

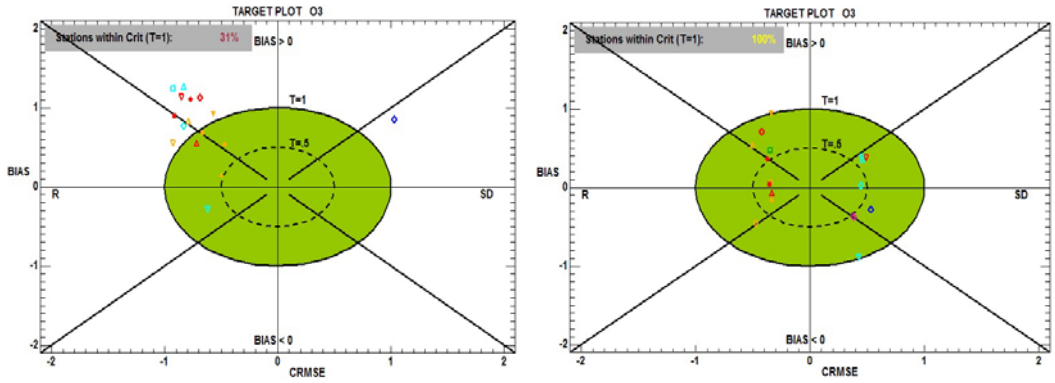

Figure 1. Target diagram for O3 8hDMax concentrations for the whole year (left) and for the summer (right).

Conclusions

Bulgarian CWFS model results have been compared to observations from 25 background stations in Bulgaria. Model performance for O_3 is better than for PM_{10} and NO_2. The model tends to overestimate O_3 8hDMax concentrations, more evident during winter. The best model results are found for the 2 rural stations (mountain stations) and for one of the coastal stations. The grid resolution of 9 km might be an explanation for better performance at rural sites. Only 31% of the stations fulfil the DMQO. The correlation coefficient varies between 0.43 and 0.72, but at half at the stations the correlation problems are indicated. For NO_2 61% of the stations fulfil the DMQO, however observations are underestimated and model weakness in representing amplitude is noticed. Daily PM_{10} values are also underestimated by the model, the target diagram indicates model problems both for correlation and amplitude and DMQO are not fulfilled at any station. Part of bad model results for NO_2 and PM_{10} might be attributed to uncertainty of emissions sources as well as to insufficient representation of local meteorological effects. However, part of the error is related to some observation data shortcoming found in daily mean values.

Exceedance of daily limit PM_{10} value at majority of the stations in Bulgaria is well known problem [5]. For 2011, 100% of the urban population was exposed to concentrations above the reference level and the trend of high mean annual concentrations is maintained [6]. Thus, providing more accurate model results for the country is actual and very challenging task.

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Oral Presentation

AIR QUALITY CONTROL IN HUNGARY: RECENT CHANGES

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Air quality monitoring

In Hungary, the high-cost standard air qualiy monitoring is a governmental task. At the same time, there are many university research groups, which study environmental issues such e.g. traffic control planning using low-cost sensors or detailed chemical analysis of aerosols for source-identification of particulate matter. This paper works with the changes in the governmental activity on this field.

In recent years, the responsibilities of governmental authorities related to monitoring and controlling air quality issues had gone through fundamental changes in Hungary. In 2010, the former Ministry for Environment Protection was dissolved and the Ministry for Rural Development became the owner of environmental issues. Two background institutes worked under the leadership of the ministry: the regional inspectorates for the protection of environment and nature, which operate the urban monitoring network and work with regulatory issues, as well as the Hungarian Meteorological Service (HMS). The responsibilities of the HMS related to the air quality control are basically organised around four main themes: measurement of background air pollution, dispersion modelling of pollutants, performance of duties of Air Quality Reference Centre as well as preparation of inventories of greenhouse gases and other air pollutants.

In 2015, the circumstances are changing again: the regional inspectorates with their regulatory and urban monitoring tasks are going to operate under a new authority called Government Offices under the Prime Minister's Office, while the legislation issues and the HMS itself stayed at the Ministry of Agriculture (the successor of the Ministry for Rural Development).

While the changes in the structure of responsible authorities raised some fundamental organisational problems, the equipments went through a big development. Due to a Swiss Contribution and the European Structural and Investment Funds, the urban monitoring network and the analytical laboratories of the inspectorates were developed by numerous new monitoring and sampling equipments, mobile measuring vans and laboratory equipments.

Air quality modelling

The European legislation supports the modelling activity on many areas of air quality issues. Measuring air pollution is an essential but costly tool of environmental protection, which gives exact time series for a single point. Effective measurement strategies and carefully organised monitoring networks increase the spatial representativity of a single measuring point, yet detailed spatial and temporal distribution of pollutants can be reached by mathematical calculations. Circulation of air, characteristics of pollutants and their emission, source distribution are fundamental terms in calculating pollution dispersion. Models calculating transmission and transformation of pollutants are effective tools in assessment of expected impacts of supposed releases (regulatory case studies) or, combining with weather prediction modelling, in estimating the expected air quality. Different air quality tasks need different models to make cost-effective calculations as the studied processes have different effects depending on the spatial and temporal resolution or the aim of the application.

The air pollution dispersion modelling is the responsibility of the Hungarian Meteorological Service. One regional and two local scale meteorological-chemical models are run at HMS.

Using the regional scale FLEXPART model, the transport and dispersion of air pollutants can be calculated in case of industrial (e.g. nuclear) catastrophes or volcano eruptions. In addition to calculating the advection of pollutants, the model takes into consideration the diffusion processes, wet and dry deposition as well as radioactive decay but does not consider the chemical transformations.

The local scale AERMOD model is applied for regulatory purposes for the long-term effects of industrial point sources.With the results of the dispersion model, the impacts of an already working or just planned industrial plant on the air quality of its surrounding areas can be evaluated. Annual mean concentrations, daily and one-hour maximum concentrations and the affected area are calculated according to the prevailing laws.

Based on the CHIMERE chemical transport model, an air quality prediction model system forecasts the concentration of air pollutants for two days in advance for the area of Budapest. The prediction system can help decision makers when the different alarm levels must be introduced. The chemical transport model calculates more than 300 chemical reactions among about 80 species. Meteorological input data are calculated with a fine-resoluion numerical prediction model, while emission input contains data for individual point sources, estimated residential and local transport emissions. The model system calculates the PM_{10}, NO_2, SO_2 and O_3 concentration values for the area with 1 hour temporal resolution. Spatial variability of various pollutants can be viewed on maps hour by hour, also, temporal variability of the four pollutants can be followed on the website of the HMS.

Conclusions

Air quality related tasks of the Hungarian authorities including high-cost standard air quality monitoring and cost-effective modelling activities are presented in this paper, indicating the capacities and possibilities a governmental control can have on this field in changing circumstances.

Oral Presentation

ON A MULTILEVEL PARAMETRIC CFD MODEL FOR URBAN AIR POLLUTION MODELLING

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Abstract

High level of air pollution in cities is responsible for many health problems. For this point both long term and short term high level exposures are dangerous [1]. We know that there can be statistically significant differences in air pollution levels of even close points along a street [2].

Decision makers often run models to predict air quality under different constraints, e.g. traffic and meteorology data. It is therefore expected that the model be fast, easy-to-use and give a high resolution in time and space. These requirements work against each other, namely high resolution in space would require complete CFD models, which are rather slow both in pre-processing and running time [3]. On the other hand, there are several canyon models that run very fast with pretty simple user interface at excellent overall accuracy [4] but they suffer from moderate accuracy under certain conditions, e.g. free ventilations of the street [5].

In this paper we present a multilevel CFD model that tries to make a compromise between the objectives. All of its main modules, in particular the geometry with mesh generation, the emission and the dispersion modules are parametric with a pretty simple user interface. It runs RANS CFD for wind field computations and diffusion-advection-reaction models for dispersion of the pollutants over very course and fine meshes of the 3D geometry according to the needs. These meshes are generated in a parametric way. Moreover, the source of the emission parts can be given parametrically or by a microscopic traffic simulation, say with VISSIM either. In the talk we describe the basic features of this model: we present, summarise and discuss several examples of evaluation studies and model applications performed with that. Finally we shall give an outlook into the developments under progress.

In order to show some insights to the content of the talk we present two illustrative examples here, with a simple and a complex geometry. The first geometry is a part of Jagtvei street with wind angle of nearly 90 degrees [6] and the second one is a pretty large area of the city of Győr, Hungary (simulation domain is of 4km x 4km x 400m); see the illustrations on Figure 1 and Figure 2, respectively.

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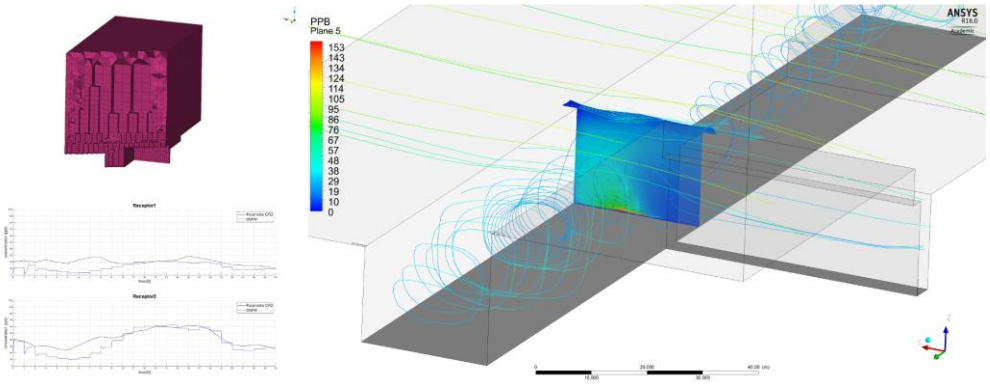

Figure 1. Mesh, graph of comparison against OSPM and flow field with NOx concentration of a full transient RANS simulation of 1 day air pollution emission and dispersion. Computational time: 860 sec on 16 cores. Pre-processing is done via scripts. Emission is not heterogeneous along the street.

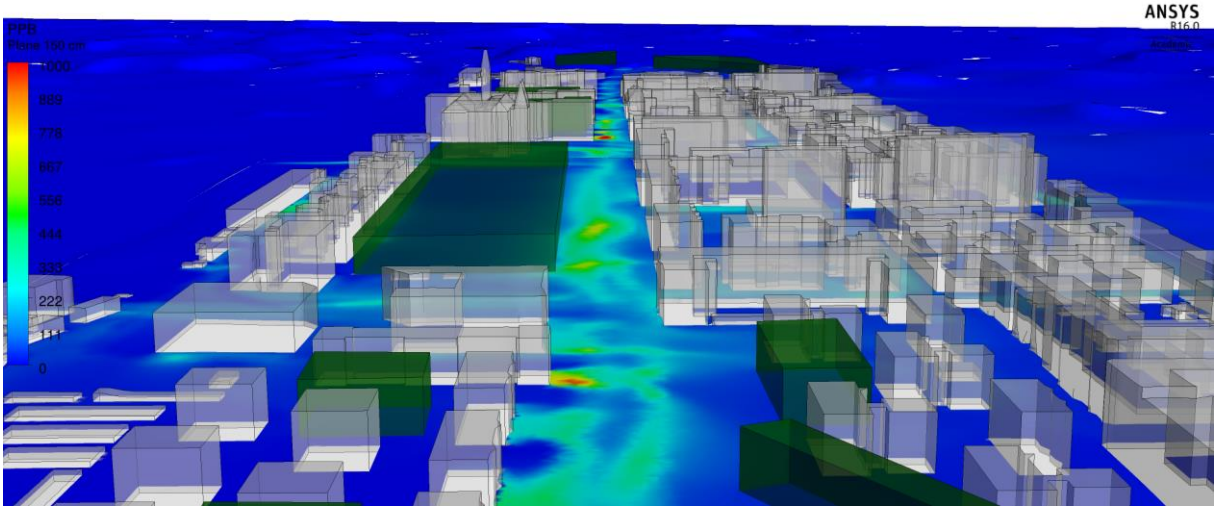

Figure 2. NOx concentration values of the simulation in Győr, Hungary, of a full transient RANS simulation of 1 day air pollution emission and dispersion. Computational time: 10 hours on 16 cores. Emission is from microscopic, validated traffic simulation.

Oral Presentation

REVIEW OF AMBIENT PARTICULATE MATTER LEVELS AND SOURCE CONTRIBUTION IN SERBIA

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Abstract

Particulate matter (PM) is the air pollutant that currently receives most attention from the atmospheric research community, the legislative authorities and the general public. European and Serbian legislation currently [1–3] regulates PM in two size fractions that are with aerodynamic diameter <10 μm (PM_{10}) and <2.5 μm ($PM_{2.5}$). In Serbia the adopted Law of Air Protection [2] and the Regulation for condition for monitoring and requirement for air quality [3] enable harmonization with EU legislation in air pollution monitoring and management. Instead of collecting total suspended particulate matter, the historically monitored air pollutant, the current Law and Regulation introduce mandatory monitoring of PM_{10} and $PM_{2.5}$, and require determination of heavy metals and benzo-a-pyrene (BaP).

Public Health Institute of Belgrade (PHI) has started first to monitor of PM_{10} in Serbia in Belgrade in 2003, while The Serbian Environmental Agency (SEPA) has started measuring air pollution including PM_{10} at automatic monitoring stations (AMS) in 2006. Jurisdiction over the national network for monitoring air quality at the level of the Republic of Serbia is SEPA that currently running 35 AMS all over the Serbia. PM_{10} and $PM_{2.5}$ are measuring at 11 AMS, 4 in Belgrade central zone. Other 7 AMS are sited in urban areas of Obrenovac, Smederevo, Novi Sad, Niš and in vicinity of cement klin in Beočin, Popovac and Kosjerić. PM levels are presented at www.sepa.gov.rs: (1) table with air pollution values in real time (update every 30 min), (2) graphs for last 24h, 3 days, 1 week and 1 month.

Further, monitoring is done under the auspices of Province of Vojvodina Secretary of Environmental Protection, http://www.eko.vojvodina.gov.rs/?q=node/264. In 2013. regional monitoring network consist of 7 AMS, where PM_{10} is collected only in town of Zrenjanin.

Pančevo, town where it the petrochemical complex, is located 13 km NE from city center of Belgrade. Municipality of Pančevo conducts monitoring of air pollution with AMS at 4 sites, where 3 sites are equipped with PM_{10} and 1 with $PM_{2.5}$ monitors http://www.pancevo.rs/Monitoring-163-1. Today there are 6 automatic stations running in Belgrade Metropolitan under PHI: local monitoring network - 2 in city center and 2 in region of Belgrade in vicinity of thermal power plants Obrenovac and Kolubara, national network - more 2 AMS located in city center. In summary of all networks, there are currently running 21 AMS that monitor PM_{10} while there are only 6 that register $PM_{2.5}$. Spatial coverage of Serbia by PM monitors is uneven as more than 70% of PM monitors are concentrated in Belgrade Metropolitan and towns in its surrounding.

Data about air pollution in Serbia have been reported into the European Environment Agency operated AirBASE since 2003. In recently published report [4], with maps for PM and O_3, that are analysis based on interpolation of annual statistics of observational data from 2012 there are presented maps for Europe including Serbia with levels of annual average of combined rural and urban background PM_{10} and $PM_{2.5}$.

For assessment of air quality in agglomerations and zones SEPA takes in account both, PM verified values from AMS and PM data collected with reference gravimetric samplers.

During 2013 [5], the annual limit value for PM_{10}, 40 $\mu g/m^3$, was exceeded on most of locations. The highest concentrations were recorded at the following locations: Valjevo (63$\mu g/m^3$), Užice (61$\mu g/m^3$) and Belgrade_Despota Stefana_PHI (55 $\mu g/m^3$). Exceedances of daily limit values, 50 $\mu g/m^3$, during 2013, occurred most frequently in Belgrade: Beograd_Despota Stefana_PHI 146 days, Beograd_Ovca_PHI 123 days, in Smederevo-Smederevo_Centar 119 days and Valjevo 118 days.

In last decade it has been performed research studies in urban areas in Serbia on the bases of data observed at local monitoring network or due to campaigns performed during winter and summer season. During winter at almost all cities PM level were twice as during summer period. Average values were >40 $\mu g/m^3$ during heating and <40 $\mu g/m^3$ during nonheating period.

Results of PM elemental composition and receptor modelling identified PM fraction levels and source contribution in Belgrade city center [6]. Results of analyses metals at 3 sites in period 2003-2006 and applied of UNMIX software identified source contribution for: $PM_{2.5}$ fossil fuel 40%, metallurgical industry 13% and resuspended road dust 47%; PM_{10} fossil fuel 34%, regional transport mainly from steel and petrochemical industry 26%, resuspended, road dust (19%) and traffic exhaust (21%).

Series of 8 campaigns were performed at one site in Belgrade central zone in framework of WeBIOPATR project (2006-2010) [7]. There were analysed metals, metalloid, cations, anions, OC/EC and 16 priority EPA PAHs. Depending on season, total carbon content was 25-40 %; ions, 20-35 %; elements, about 5-10 % and content of 30-40 % of PM_{10} mass was chemically unidentified. Analyses suggest differences in source contribution during winter and summer seasons. Contribution of PM from traffic is higher in winter than in summer. Biomass burning including domestic heating was identified as the most dominant man-made source in winter. Other significant sources include soil erosion and secondary aerosol formation that are dominant in summer. The total mass of 16 measured PAHs in PM_{10} is much higher in winter (29 ng/m^3) than in summer (2.4 ng/m^3); ratio of PAH in PM_1 to PM_{10} is about 0.5 for both seasons. Average values of BaP are higher than 1 ng/m^3 in winter and less than 0.1 ng/m^3 in summer period in both PM fractions, PM_{10} and PM_1.

Tasic *et al*. [8] compared PM_{10} and $PM_{2.5}$ mass concentration in urban industrial area and in its rural surroundings. There is a significant seasonal difference in $PM_{2.5}$ levels on all rural sites, because they are affected by domestic heating emissions in cold periods. Compared to EU countries, there is a lack of PM data and research studies from Serbia not only for rural and sub-urban areas, but also for urban areas.

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Oral Presentation

THE MOSSCLONE FP7 PROJECT: MONITORING AIR QUALITY USING MOSS AS PASSIVE SENSOR

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Abstract

The task of monitoring airborne trace element pollution over large areas is somewhat arduous, since the concentrations of pollutants are very variable in space and time. In addition, data from automatic devices are accurate but too limited in number to describe spatio-temporal trends of pollutants. Furthermore, automatic devices at monitoring stations can generally detect a limited number of pollutants (mainly CO, SO_2, NO_x, PAHs and particles). In view of this, it is clear that at present it is necessary to have new inexpensive and robust tools for monitoring air quality. Due to the limitations of traditional methods, bio-monitoring is an adequate alternative to acquire data about the levels of pollutants. These techniques consist of the analysis of organisms which are reactive to pollution, in order to estimate deviations from 'normal-control' conditions. Moreover, bio-monitoring makes it possible to evaluate the state of environmental parameters influenced by synergistic effects of different pollutants on organisms.

Among the available bio-monitors, terrestrial mosses are especially adequate for air quality assessment due to their high efficiency in loading both particulate and gaseous determinants of organic, inorganic, and radioactive pollutants. Mosses lack of a root system, so they rely on atmospheric wet and dry deposition for their mineral nutrition, they have a high surface/mass ratio and own ion exchange properties. Their bio-accumulation efficiency comes from their substantial cation exchange capacity, which is due to negatively charged cell wall constituents (mostly carboxylic acid groups) that can establish ionic bonds with cationic elements in soluble form. Elements can also be retained in particles trapped in intercellular spaces.

The absence of well-suited moss species living in urban, extra-urban, and even indoor reference environments, and the difficulty of choosing ideal sampling conditions for convenient area distribution, encourages the use of moss transplants to gather air pollution data over large areas. This approach, also called 'active' bio-monitoring, offers several advantages because: *i*) the material can be exposed according to a rational scheme, *ii*) it is possible to calculate enrichment rates since pre-exposure values are known, and *iii*) the monitoring can be repeated. The use of transplants is becoming quite common particularly after the adoption of the so called 'bags', small envelops of a variety of forms and materials containing the material to be exposed. The design of the active bio-monitoring should involve transplants of similar and well defined initial conditions (e.g. similar morphology, well-characterized initial contents, comparable physiological status, etc.).

Among the problems that can arise when using mosses for moss-bags preparation we can highlight two. Firstly, these bags are prepared from mosses naturally grown in unpolluted areas, so its availability could vary depending on natural and anthropogenic causes. And secondly, the natural variability on moss elemental composition (including pollutants) results in variation of the initial conditions of moss-bags over time. A possible solution to avoid both problems is to cultivate the moss in laboratory to always have homogeneous material to prepare the bags. In addition, if a clone of one moss species would be available, as occurs in

other bio-monitors as clover for ozone monitoring (i.e. clones NC-S, sensitive, and NC-R, resistant), a high degree of standardization would be reached. In view of all this, *MossClone* project (www.mossclone.eu) proposes the use of cultivated mosses as a tool for air pollution monitoring. An additional, but highly relevant problem that usually affects the use of bio-monitors is the lack of standardized protocols and methodologies. The lack of such protocols hampers comparison of the results obtained in different studies, and sometimes limits the conclusions that can be reached. The *MossClone* approach, using cloned mosses for the standardization of bio-monitors (moss bags), would overcome all these issues, thereby improving data quality and reproducibility, and therefore usability of environmental data.
The project full title is: *'Creating and testing a method for controlling the air quality based on a new biotechnological tool. Use of a devitalized moss clone as passive contaminant sensor'* (acronym *MossClone*) and it is a collaborative project corresponding to the call FP7-ENV.2011.3.1.9-1: Eco-innovation! The research consortium, led by the University of Santiago de Compostela (Spain), involves academic institutions and small-medium enterprises from France, Germany, Italy, Ireland and Spain. The main objectives are: *i*) selection and culture of the most suitable moss species; *ii*) morphological, molecular, physical, chemical and multi-elemental characterization of the selected clone; *iii*) large-scale production of the moss; *iv*) design and production of a new device for transplants; *v*) Methodological standardization for using moss-bags (i.e. net mesh, shape and weight/surface ratio of bags, and also exposure height and duration); *vi*) comparison between data collected using moss-bags and traditional techniques (i.e. bulk deposition collectors, airborne particles and gaseous pollutants samplers); and *vii*) development of a method for the detection of atmospheric small-scale pollution focus using moss clone bags.
In order to evaluate the influence of land use and climate on moss uptake, the test exposures were performed in background areas, urban, industrial, and agricultural sites from Austria, Italy and Spain. Figure 1 shows some examples of different types of moss-bags compared (A and B), one of the devices used for the study of exposure height on pollutant accumulation in moss-bags (C), and also some traditional techniques used to compare with moss-bags (high volume PM_{10} sampler and bulk collector). The most important outcome of the project was to have been able to standardize the moss material (isolating and culturing a clone of *Sphagnum palustre*) and to standardize the exposure protocol (e.g. type of moss-bag, ratio weight/surface, height, etc.), so the clone obtained can be used to obtain information on levels of airborne pollutants on a reliable way and at low cost.

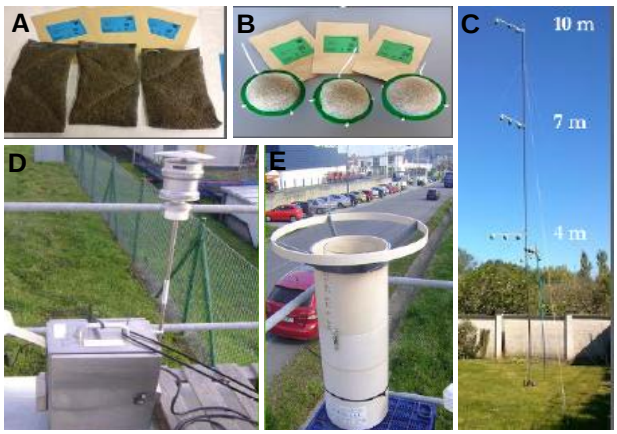

Figure 1. A and B. Different types of tested moss-bags. C. Device used for analysis of height effect on moss-bags pollutants uptake. D. High volume sampler for PM_{10}. E. Bulk collector for PAHs sampling.

KERNEL NETWORKS FOR LEARNING FROM SENSOR DATA

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Abstract

In this paper we study one supervised learning technique - the so-called *regularization network (RN)*. RNs are feed-forward neural networks with one hidden layer. They benefit from a good theoretical background, their architecture has been proved to be the solution of the problem of learning from examples when formulated as a regularized minimization problem [4]. The performance of the RN learning depends significantly on the choice of kernel function, and moreover, the choice of kernel function always depends on a particular task at hand [3]. Different kernel functions are suitable for different data types, but one often has to deal with heterogeneous data, in the sense that attributes differ in type or quality, or that the character of data differs in different parts of the input space. Therefore, we propose network architectures using composite types of kernels that might better reflect the heterogeneous character of data. These kernel types include either a sum of selected kernel functions or a tensor product of functions operating on a split subsets of input variables [5]. This split, as well as the types and parameters of kernel functions, are adaptively set by an original neuro-evolutionary learning algorithm, in our case. Our approach can be ranked among the so called multi-kernel models. The approach is tested on a real-world data from the area of sensor networks for air pollution monitoring. We use data from De Vito et al [1], [2], that describe a supervised learning approximation problem. The data contain tens of thousands measurements of gas multi-sensor devices recording concentrations of several gas pollutants.

In our approach we use *genetic algorithm* (GA) to search for different type of kernel units, including product kernels. The GA works with a population of individuals embodying abstract representations of feasible solutions. Each individual is assigned a fitness that expresses a measure of how good solution it represents. The population evolves towards better solutions by means of selection, crossover and mutation procedures. We use floating point encoding, a combination of one-point and arithmetic crossover, and a small-rate local mutation operator.

The dataset contain tens of thousands measurements of gas multi-sensor MOX array devices recording concentrations of several gas pollutants collocated with a conventional air pollution monitoring station that provides labels for the data. The data are recorded in 1 hour intervals.

Table 1: Comparison of training and testing errors for networks trained on single epochs.

Training errors

	Gaussian kernel				Product kernels			
Task	E_{avg}	stddev	min	max	E_{avg}	stddev	min	max
CO-i1	**0.050**	0.000	0.050	0.050	0.051	0.002	**0.049**	0.055
CO-i2	0.049	0.000	0.049	0.049	**0.046**	0.002	**0.043**	0.050
CO-i3	**0.054**	0.000	**0.053**	0.054	0.056	0.003	0.054	0.065
CO-i4	**0.333**	0.001	0.332	0.334	0.347	0.016	**0.325**	0.378
CO-i5	0.133	0.000	0.132	0.133	**0.097**	0.018	**0.077**	0.142
NO2-i1	**0.096**	0.002	0.093	0.101	0.100	0.015	**0.091**	0.141
NO2-i2	0.133	0.001	0.131	0.134	**0.122**	0.014	**0.105**	0.148
NO2-i3	0.388	0.001	0.384	0.389	**0.314**	0.077	**0.214**	0.434
NO2-i4	0.297	0.002	0.295	0.299	**0.287**	0.012	**0.265**	0.307
NO2-i5	**0.375**	0.001	0.374	0.376	0.389	0.032	**0.330**	0.435
NOx-i1	0.018	0.000	0.018	0.018	**0.017**	0.001	**0.016**	0.020
NOx-i2	0.026	0.000	0.026	0.027	**0.025**	0.002	**0.021**	0.028
NOx-i3	0.156	0.001	0.154	0.158	**0.152**	0.019	**0.121**	0.184
NOx-i4	0.231	0.002	0.229	0.234	**0.230**	0.017	**0.203**	0.258
NOx-i5	0.106	0.023	0.087	0.132	**0.095**	0.011	**0.083**	0.122

Testing errors

	Gaussian kernel				Product kernels			
Task	E_{avg}	stddev	min	max	E_{avg}	stddev	min	max
CO-i1	**0.210**	0.005	0.205	0.217	0.214	0.020	**0.192**	0.248
CO-i2	1.134	0.007	1.116	1.142	**0.878**	0.088	**0.709**	0.988
CO-i3	0.233	0.009	0.221	0.254	**0.228**	0.019	**0.197**	0.267
CO-i4	**0.326**	0.002	**0.323**	0.329	0.749	0.512	0.433	1.921
CO-i5	**0.296**	0.005	0.287	0.301	0.321	0.050	**0.204**	0.374
NO2-i1	**2.151**	0.052	2.096	2.267	2.263	0.540	**1.189**	2.997
NO2-i2	5.260	0.045	5.161	5.319	**3.928**	1.447	**2.661**	6.874
NO2-i3	**0.718**	0.004	**0.709**	0.721	1.033	0.218	0.764	1.351
NO2-i4	0.735	0.011	0.726	0.757	**0.734**	0.069	**0.669**	0.908
NO2-i5	**0.678**	0.024	**0.655**	0.735	0.913	0.183	0.709	1.302
NOx-i1	2.515	0.015	2.495	2.538	**2.409**	0.159	**2.093**	2.658
NOx-i2	3.113	0.019	3.081	3.139	**2.495**	0.068	**2.416**	2.592
NOx-i3	1.105	0.008	1.088	1.114	**0.956**	0.267	**0.730**	1.689
NOx-i4	**0.952**	0.008	0.941	0.970	1.256	0.520	**0.774**	2.610
NOx-i5	**0.730**	0.102	0.642	0.850	0.748	0.091	**0.544**	0.856

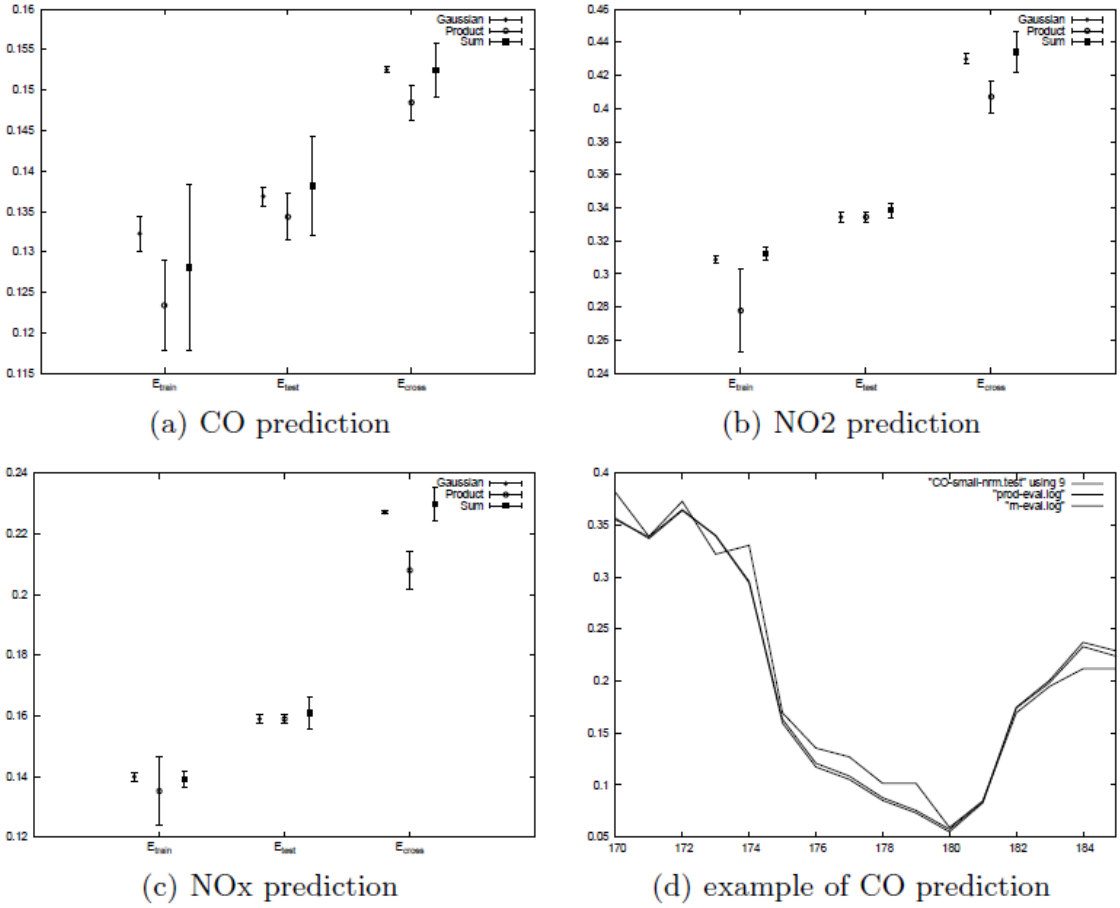

Figure 1: Training, test and crossvalidation errors for various kernels. Prediction of CO on test data.

In the first experiment, we use spare measurements for training, i.e. the training data consists of 4 samples per day. The rest is then used for testing. The second experiment divides the whole time period into five intervals. Then, only one interval is used for training, the rest is again utilized for testing. We considered three different choices of the training part selection. This task may be more difficult, since the prediction is performed also in different parts of the year than the learning. For the first task product kernels provided the best generalization while the training error is similar to alternative methods (cf. Figure 1). For the second task, the product kernels gave better generalization in 10 cases out of 15 (cf. Table 1).

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Invited Talk

SEVERAL WAYS TO GET MORE DATA OUT OF CHEMOSENSING

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Abstract

While more sensitive chemical sensors are easily obtained by using very thin sensitive layers and through the miniaturization of devices, it is not the same for selectivity. In the past, the juxtaposition of nonselective sensors in recognition systems such as the electronic noses was often proposed as a way to improve detection systems. These instruments, which combine an array of electronic chemical sensors with partial specificity and an appropriate recognition system, are capable of recognizing both simple or complex atmospheres [1]. However, that does not answer effectively the need for selectivity, because of the drift in time of the individual sensitive elements. As a result, the peak of sale of such systems, reached in 1997, has been followed by a sharp decline. In this communication, we will discuss multi-parameter measurement systems (Fig. 1) and different ways that can be used to improve on selectivity, via the accumulation of data and their treatment by principal component analysis (PCA), artificial neural networks, and any other methods [2].

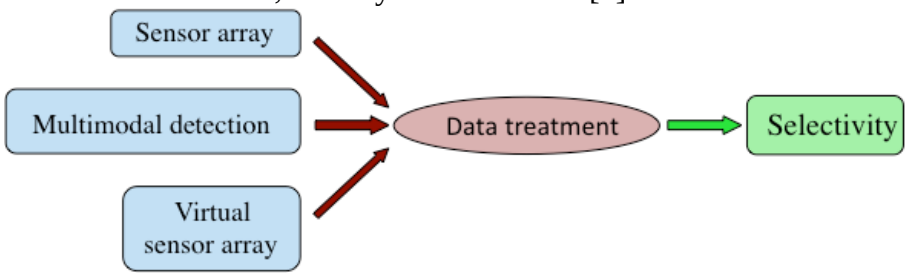

Figure 1. Scheme of the different ways to reach selectivity in chemosensing

Among the reported **sensor arrays**, we can distinguish two groups. First, the system based on non-stoechiometric oxides of the SnO_{2-x} type, which suffer from the lack of selectivity of individual sensors that limits their development [3,4]. The second group concerns the sensors arrays made from molecular materials, such as porphyrins and phthalocyanines. The works of I. Lundström applied to the discrimination between various fruit juices [5] and that of R. Paolesse devoted to the study of the fish freshness [6] can be cites as examples. These systems, although yielding good performances at the laboratory stage, suffers from a major drawback: The complexity of the models and the length of the learning phase coupled with the lack of stability in time of the individual sensors.

Another approach is to use simultaneously **several transduction modes**. For instance, conductometric, electrochemical and optical techniques were associated together in a sensor array, by the team of M. - L. Rodriguez-Mendez, and used for wine analysis [7]. As before, the research and development tasks led to a new analytical tool that was however, much closer to a traditional analyzer than to a sensor microsystem, considering its bulkiness and cost. As an alternative route, the combination of two transduction modes that are sensitive to two distinct and complementary physical phenomena, applied to/used on the same material interacting with the same atmosphere to analyze should lead to a powerful selective sensor system. As an example of this approach implementing a double transduction mode one can cite the coupling of conductometric and acoustic measurements by Janata, who modified quartz microbalances with a piezoelectric material [8]. We proposed a multimodal detection, based on two transduction modes: Conductometric transducers on one hand, and microwave

transducers on the other. The conductometric transducer is mainly sensitive to redox active species, electro-withdrawing or electro-donating species. These species will mostly induce a variation of the transport properties: Firstly the charge carrier's density and to a lesser extent the mobility of these carriers. Microwave transduction mainly probes the variation of the permittivity of the sensitive material resulting from the adsorption of molecules onto the sensitive layer. Thus, the variation of the permittivity of the medium is the main phenomenon in this technology. On the other side, it has a little effect on conductometric transducers. The originality in this approach is that it aims at associating two transduction modes that are sensitive to two distinct and complementary physical phenomena on one material interacting with one atmosphere to analyze [9].

As a result, using a single sensor, it is possible to measure several independent parameters, resulting in a so-called a **virtual sensor array**. This can also be obtained by operating the very same sensor at different temperatures [10]. It is also possible to operate at different frequencies and obtain a spectral response that includes significant data. This is however limited to few transduction modes. The microwave technology based on the dielectric response of a material to a gas subjected to a microwave-type electromagnetic field was very recently proposed and validated with non-stoechiometric tin dioxide as sensitive material and a series of alcohols and aromatic molecules as analytes, and with a phthalocyanine for the detection of toluene [11]. This variation specific to a gas and a material strongly depends on the working frequency. Thus, with the means of a vectorial network analyzer, sweeping in a broad frequency band (30 MHz - 20 GHz) leading to a dielectric spectrum characteristic of this interaction.

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Oral Presentation

APPLICATION OF CHEMIRESISTIVE POLYMER FILMS IN AIR QUALITY CONTROL

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History of application conductive polymers or polymer composites in gas sensing is not long time ago. *Okazaki* in 1999 reported about determined polymer-carbon nanoparticle composite electrical resistance change in presence of VOC [1]. Since that time a lot of research has been done to investigate: *i*) VOC sensitivity of different compositions varying conductive fillers and polymers; *ii*) the sensing mechanism and experimentally prove it; *iii*) cross-sensitivity and selectivity. However, long term stability of polymer based gas sensors is an issue, which demands improvement.

Nowadays importance of air quality control is even increased, because people daily habits are changed and more time is spent indoors or urbanised territories. In todays perspective chemiresistive polymer films (CPF) as a tool for air quality control is highly attractive and I will explain why. Comparing to other sensing devices CPF are selective. It means that composite response to different VOC like toluene, benzene, ethyl acetate, acetone and etc. deviates [2-4]. *Zeng W.* even describes possibility to distinguish VOC by the molecule size [3]. Results obtained at lab show that CPF are sensitive enough - concentrations greatly below VOC regulated exposure limits can be sensed, for example, toluene 10-15 ppm was detected by composite made of thiophene based conducting polymer and carbon black nanoparticles [5]. CPF operate at room temperature, therefore low power air quality control devices can be made. Cost of CPF based sensing element is low and has potential to be easily mass-produced by printing [6].

Composite sensing mechanism of gases determines which gases could be detected by certain composition. Best results for non-conductive polymer composites are obtained when these composites are applied for VOC detection. Data available in literature evidence that conductive polymer nanocomposites, for example, polyaniline(PANI)-Ag nanocomposite, PANI-single wall carbon nanotubes composite or PANI-metal salt ($CuCl_2$) are more preferable for inorganic gas detection like SO_2, CO_2, H_2S and NH_3. Promising sensing results have been reported in literature for conductive polymer nanocomposites reaching 1 ppm detection limit of inorganic gases. According to OSHA data time weighted average (TWA) for SO_2 - 2 ppm, CO_2 - 5000 ppm, H_2S - 10 ppm and NH_3 - 50 ppm.

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Oral Presentation

ELECTROCHEMICAL PROCESSES TO FUNCTIONALIZE NANOSTRUCTURED SENSITIVE LAYERS FOR NO_2 GAS SENSORS

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Abstract
The development of gas sensors to detect toxic and combustible gases is essential due to the concerns for environmental pollution and the safety requirements of industry. In this context, chemical sensors have revealed a profound influence on personal safety, medical diagnosis, detection of pollutants and toxins, and the transportation industries [1, 2]; specifically, carbon nanotubes (CNTs) and nanostructured metal oxides (MOx) have been both extensively used as sensing layer in chemiresistor gas sensors [3-5]. Although these materials have both advantages and drawbacks in gas sensing application, in both cases the surface functionalization is necessary to improve their gas sensing properties, such as sensitivity and selectivity. In particular, it has been demonstrated that the surface functionalization by gold nanoparticles (Au NPs) on CNTs and MOx improves their stability and the sensitivity and selectivity to NO_2 gas detection [6-8].
Among different processes used to decorate the surface of CNTs and MOx nanostructures, in this contribution we propose electrochemical processes as a powerful tool to directly surface functionalize CNTs and ZnO nanostructures with Au NPs of shape, dimension and loading finely tuned by a proper selection of the electrochemical parameters (e.g. applied potential, total charge, electrolyte composition) [9, 10]. A description of electrochemical methods used to Au NPs-functionalized CNTs and ZnO nanostrctures will be provided, along with chemical and morphological characterization. Moreover, the gas sensor performance of chemiresistor devices consisting of pristine and Au-decorated CNTs and ZnO will be reported, evaluating the sensitivity and selectivity to NO_2 gas respect to interfering gases (e.g. NH_3, CH_4, CO).
Finally, the successful result in NO_2 gas sensing, obtained using the Au-decorated sensing materials, as reported in Figure 1, demonstrates the effectiveness of electrochemical functionalization processes; indeed, the proposed methods permit a fine control of the deposited gold loading, preventing clustering so as to ensure its catalytic activity necessary to improve the gas sensing properties of pristine material.

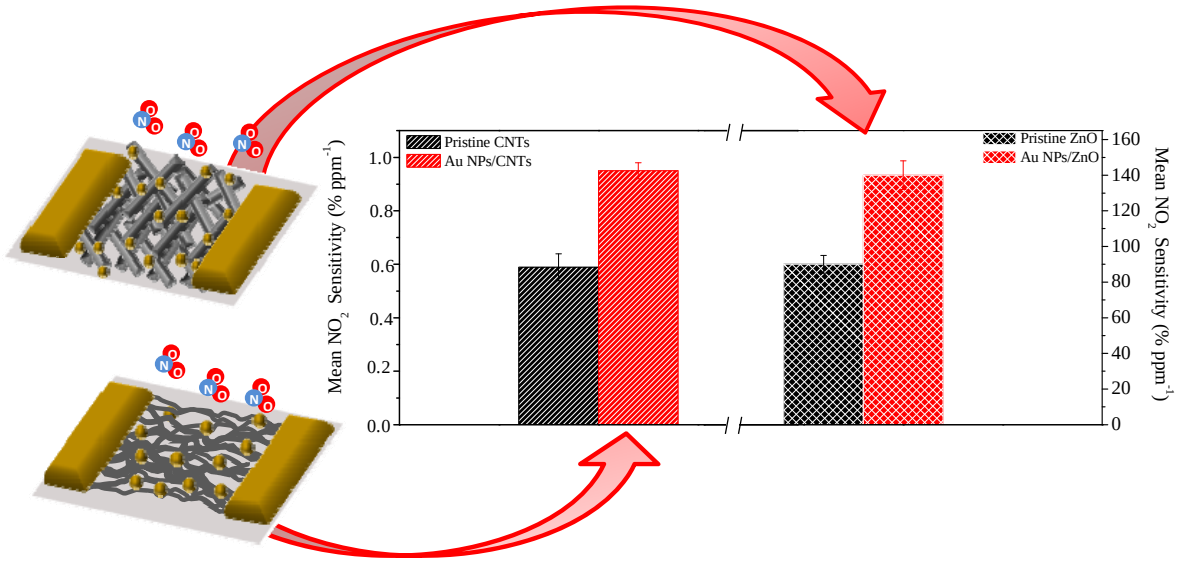

Figure 1. Mean NO_2 sensitivity of electrochemically Au-functionalized and pristine CNTs and ZnO-based chemiresistive gas sensors.

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Oral Presentation

GAS SENSORS AND ARTIFICIAL OLFACTION INSTRUMENTS - RESEARCHES AND APPLICATION AT UNIVERSITY OF LATVIA

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Abstract

The contribution of Latvian scientists to odour and artificial olfaction researches must start with Andrey Dravnieks (1912-1986), famous Latvian Chemist [1]. He received his Master's degree in chemical engineering from the University of Latvia in Riga, and a Doctorate in physical chemistry from Illinois Institute of Technology when he immigrated to USA after SWW (1946). Andrey Dravnieks developed original techniques for collecting, concentrating and trapping odorous atmospheres and for analyzing them, developed widely used nowadays olfaction method, consisting from sniffing panellists and diluted odours [2,3]. He was also the first using discriminant analysis in processing the data from panellists and gas chromatograms of odorants, and his greatest work at the end of life was ASTM Data Atlas of odour character profiles [4].

Different gas sensing materials and sensors were elaborated and researched at ISSP UL during 1980-1990ies [5-7], but interest in artificial olfaction instruments started from 1994 when cooperation was established with Linköping University (Prof. Ingemar Lundström, Dr. Anita Lloyd-Spetz) [8-9]. As instrument the electronic nose at ISSP UL appeared in 1997, from "Nordic Sensors AB" (Sweden), containing 14 gas sensors - 10 MOSFETs with different gas sensing electrodes (Pt, Pd, Ir and their alloys) and temperature gradient from 115 to 150 ^{o}C, and 4 high-temperature semiconductor oxide resistive sensors (TGS-813; 800; 881; 825). Different applications were tested together with second instrument z-Nose (Electronic Sensor Technology, USA) - portable gas chromatograph coupled with extremely sensitive surface acoustic waves sensor [10,11]. Together with engineers from Riga Technical University micro-system prototype for the mobile artificial sensing instruments was constructed, using HW/SW co-design as tool to create it. Microcontroller (Texas Instrument 3705x) was used as control module to deliver gas, control of sensor array and perform data acquisition [12].

The 10th International Symposium on Olfaction and Electronic Nose, ISOEN'03 was organized in Riga (Latvia), at University of Latvia, in June 25-28, 2003. 93 participants from 22 Countries visited Riga to discuss main results in sensor and sensor array technologies, e-nose miniaturisation, odour description in electronic files and unified description language formation, e-nose applications in different fields, making emphasis on product adulteration and environment pollution control.

Later we had an interest in the use of e-nose for human health status monitoring, and research began with the athletes who were prepared for the Olympic Games. The first idea was to find in breath lactic acid, which is indicative of muscle fatigue pregnant [13]. Cooperation started with the Faculty of Medicine at University of Latvia to study early diagnostics possibilities for pulmonary diseases. The aim of this investigation was to identify odour characteristics for lung cancer of lung disease patients by comparing breath patterns of specific lung's diseases, and by comparing such patterns for patients before surgical operation (removal of a sick part of the lung) and after that [14].

Collecting samples of exhaled breath from people at a high risk of lung cancer could be a cheap and non-invasive method of diagnosing the disease. The ERAF 2.1.1.1 project "*Development of lung cancer diagnostic methods and software prototype using expiratory air analysis with artificial olfactory sensor*" was performed in University of Latvia in 2011 - 2013. Researchers collected and analyzed exhaled breath samples using new generation 32 eletronic nose sensor device Cyranose 320 (*Smith's Detection Ltd, USA*) from 1232 lung cancer patients, patients with different lung diseases and healthy volunteers [15]. Development of new diagnostic algorithm taking into account exhaled breath analysis data in combination with lung cancer risk factors allowed to predict correctly lung cancer diagnosis with sensitivity up to 99.3% and specificity up to 97.3% in training group, and 86.0% and 87.0% respectively in the test group [16]. Authors have shown that it is possible to use breath tests to correctly identify lung cancer with a high sensitivity rate [17]. The results of our study take us one step further to understanding this important new technology.

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Invited Talk

GAS SENSORS - FIRE DETECTION AND BEYOND

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Abstract

Since Francis Robbins Upton invented the first automatic electric fire alarm in 1890, devices to detect fires have found widespread use in all types of buildings. The coverage in US domestic households is estimated to be above 93%. In EU-countries the coverage is varying depending on local regulations.

The vast majority of these devices referred to as fire detectors are sensing smoke as an indicator of fire. The principle of detection is mostly based on optics or in older systems based on the ionization of air using radioisotopes. The main drawbacks of this type of sensor are possible false alarms in areas with lots of particles or aerosols in the air and a difficulty to detect fires that do not generate much smoke (e.g. ethanol fire, some smoldering fires).

Gas sensors that detect the chemical compounds produced by fires (CO, NO_x, CO_2, specific VOCs...) can improve that situation by detecting fires in a very early stage and discriminating them against nuisances that would cause false alarms in conventional detectors. The feasibility of this type of innovative fire detection has been demonstrated within numerous funded projects. The main hurdles to get this to the marked are the extensive and costly certification process for fire gas detectors.

In addition to using fire gas detectors based on gas sensor arrays only for fire detection, these devices can provide much more valuable information if they are integrated into a sensor network. The data from these sensors provides information about parameters like air quality (VOCs/CO_2), occupancy/activity or hazardous gas concentrations.

The main benefit is that the data acquired by a fire gas detector during normal operation is no longer discarded but instead used for other applications of building management systems. This comes at very low additional costs for the system but would reduce the number of separate sensing devices in a room.

Oral Presentation

SILICON-ON-INSULATOR MICRO-HOTPLATES PLATFORMS FOR HUMIDITY SENSING: FOLLOW-UP OF THE AIR QUALITY INTERCOMPARISON EXERCISE

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In this paper, the performances of a micro-machined water vapour sensor are reported. The sensor is made of interdigitated microelectrodes (IDE) suspended on a silicon-on-insulator (SOI) micro-hotplate as presented on Fig. 1. In opposite to conventional polymer-based humidity sensors [1-2], the proposed relative humidity (%RH) sensor exploits a ceramic 25 nm-thick Al_2O_3 coating deposed by atomic layer deposition (ALD). This sensitive layer allows ultrafast response time (< 0.5 s) and simple post-process built-in compared to optical detection [3] or less common materials as porous silicon [4].

A Freescale™ KL25Z datalogger connected to the humidity sensor microsystem was placed on the roof of the Instituto do Ambiente e Desenvolvimento (IDAD) car, as pictured in Fig. 2. The temperature was given by the MLP3115 on the Freescale board. The relative humidity (%RH) and temperature (T) data are presented in Fig. 3. The %RH variations are transduced into capacitance then converted to frequency variations thanks to a ring oscillator (RO) interface designed on that purpose in a commercial CMOS technology. For high (low) %RH levels, the IDE capacitance increases (decreases), and so goes the RO period. A humidity sensor from K. Karatzas (Aristotle University of Thessaloniki) was included in the same all-weather housing. The comparison with %RH reference sensors is not straightforward because of large discrepancies between the references. For example, during the day of the October 22nd, differences as large as 9 °C and 25%RH were monitored by the possible reference sensors: (*i*) IDAD WTX520: 26.8 °C and 85%RH, (*ii*) IDAD GrayWolf: 29-31 °C and 75%RH, (*iii*) K. Karatzas %RH sensor: 28.5-32 °C and 99%RH and (*iv*) the Freescale MLP315: 36 °C. Errors, sun exposition, ventilation, packaging, self-heating and possible condensation considerably influence the local atmospheric conditions and complexity the comparison exercise.

Measurements tests in a climatic chamber (ESPEC SH261) were therefore performed to simulate weather conditions with 45 to 90%RH (1%RH steps) sweeps and 15 °C to 35 °C (1 °C steps) sweeps. At 25 °C, the sensitivity to %RH is equal to ~2.5%/%RH for ALD-coated sensors while ~80 ppm/%RH for uncoated ones. Fig. 4 presents the measurements at 18 °C for an ALD coated sensor. The RO frequency output is almost linear (2% non linearity error) and shows ±2% %RH level accuracy (with 2-points calibration). More details will be given during the talk.

Finally, the %RH sensor and its circuitry (see Fig.1) achieve a very low power consumption of ~200 µW under Aveiro experience conditions.

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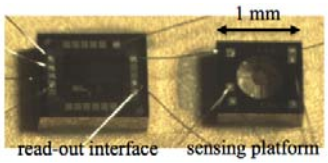

Fig. 1: Close view of SiP forming the readout interface and the %RH sensor

Fig. 2: Sensors location during the Aveiro comparison exercise

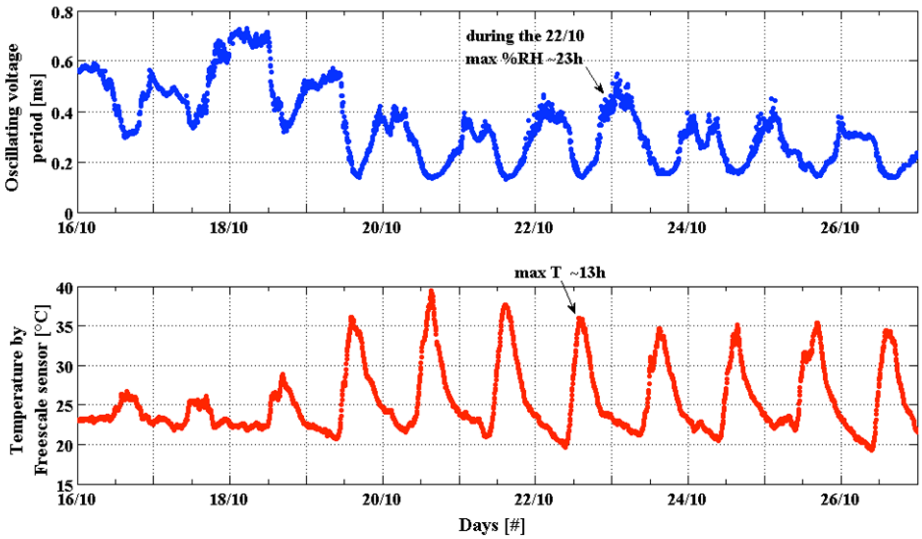

Fig. 3: %RH sensor oscillating voltage period output and temperature from Aveiro experience.

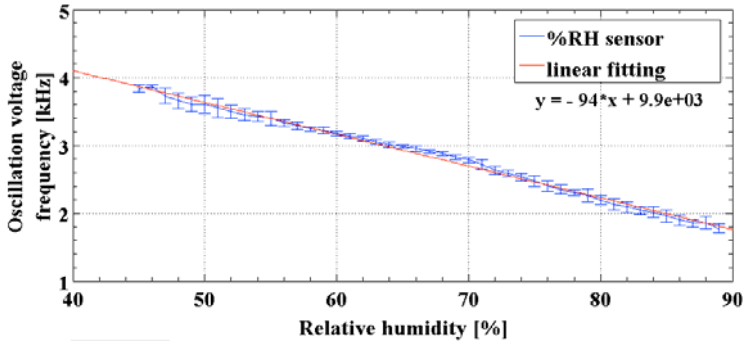

Fig. 4: %RH sensor oscillating voltage frequency, tested in climatic chamber at 18 °C and from 45 to 90%RH.

[1] Sensirion SHT series, www.sensirion.com
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Oral Presentation

EXPANDING THE CAPABILITIES OF CO_2 LIDAR SYSTEM WITH NONLINEAR OPTICAL CHALCOGENIDE CRYSTALS

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Abstract

DIAL LIDARs are robust systems for remote atmospheric gases detection that can be used from a distance up to 15 km to the measured area. However, their capabilities are limited for the following reasons:

1. There are no commercial lasers that could be used in the 3-6 μm spectral range which would be very useful in atmosphere monitoring
2. Absorption peaks of different gases overlap resulting in detection errors and limited selectivity of the LIDAR detection system

We propose to tackle the above issues and expand the capabilities of a CO_2 DIAL lidar system by application of nonlinear optical (NLO) chalcogenide crystals [1]. Firstly, such crystals are able to convert part of the fundamental laser beam of wavelength λ to different wavelengths such as λ/2 (Second Harmonic Generation), λ/3 (Third Harmonic Generation) and possibly also to sum differences and parametric generation. As can be seen in Figure 1, in addition to a tuneable 9-12 μm CO_2 laser emission this would extend the spectral range to 3-4 μm and 4.5-6 μm which would enable one to perform the measurement in two additional atmosphere transmission windows. These additional wavelengths are of great interest as they would allow for the detection of gases such as methane or nitrous oxide. This not only solves aforementioned Issue 1, but in theory also enables simultaneous detection in all three regions. Even if the frequency conversion yield is too low for simultaneous measurement at different wavelengths, it will be fairly easy to switch the detection wavelengths in several seconds or less.

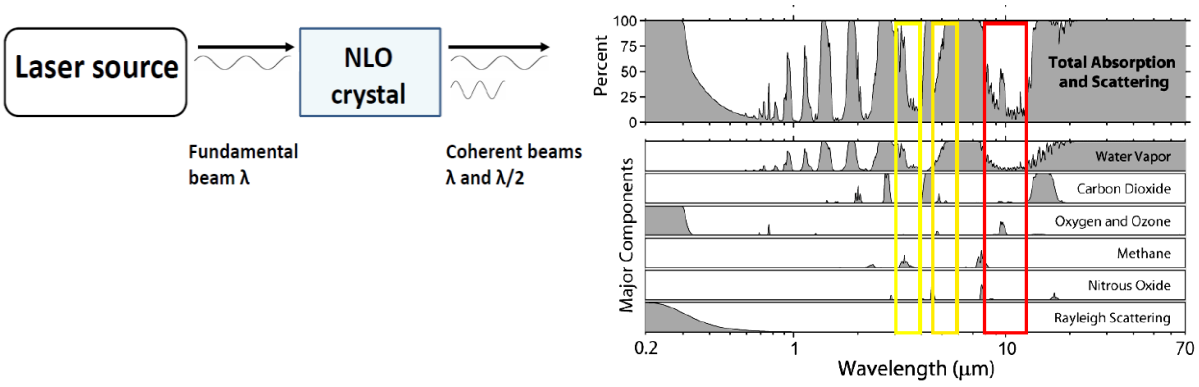

Figure 1 Left: schematic representation of frequency doubling (SHG) with a nonlinear optical crystal. Right: detection range of DIAL CO_2 system: red - current range 9-12 μm; orange - additional SHG range 4.5-6 μm; yellow - additional THG range 3-4 μm

Limited selectivity - Issue 2 - can also be partially solved by application of NLO crystals due to the fact that the two waves (fundamental and second harmonic) are coherent. The pulsed

laser used in the LIDAR system emits with relatively high energy density and when two coherent beams are involved there exists additional nonlinear optical interaction of light with gaseous molecules. Such interaction involves not only harmonic vibrations, but also anharmonic ones which are specific to each molecule. It is noteworthy that increase of this interaction by just 1% leads to 10% signal increase. It can be especially useful in the case of overlapping absorption signal of two different gases.

The main challenge that has to be resolved in order to prepare a practically applicable DIAL-NLO system is to find and prepare a suitable crystal. Firstly, it has to be transparent in the spectral region of interest. For this reason the widely studied and commercially available oxide crystals cannot be applied and a different class has to be used, such as chalcogenides. Secondly, the crystal needs to be characterized by good thermal stability, birefringence and exhibit good phase matching properties.

In our studies so far the best results have been obtained with : Ag_3AsS_3, Ag_3SbS_3, $AgGaSe_2$ [1,2], Tl3AsSe3 [3], $CdGeAs_2$ [4,5]. The best conversion yield to SHG was 27%. We are currently studying $AgGaGe_xSe2_{x+2}$ (x=2,3,4,5) tertiary crystals with promising preliminary results.
In summary, addition of a NLO module to a LIDAR system substantially increases the spectral range of atmospheric detection at the same time improving the selectivity. It is important to note that the estimated cost of upgrading a CO_2 LIDAR system to the DIAL-NLO standard is approximately 20 000 EUR which is only about 10% of the equipment cost. Considering the expanded capabilities described above we believe that the NLO solution is interesting for both practical and economic reasons.

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Oral presentation

MOBILE AIR QUALITY MONITORING WITH LOW-COST SENSORS - PILOTING EXPERIENCE IN ZAGREB

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Abstract

Personalized management and long-term medical studies of prevalent chronic respiratory disease, such as allergic asthma, are possible by assessment of personal air-pollution exposure, characterization of urban-canyons' or industrial site fence-line monitoring. Dense networks of low-cost mobile air-quality sensors [1], [2] are often proposed for high spatial data resolution required by such applications.

We present our experiences from development and field deployments of a "crowdsensing" (e.g. "participatory sensing") system, enabling the information from the existing air quality measurement infrastructure to be supplemented by data collected by mobile sensors carried by participating citizens. The system uses a smartphone for real-time data collection, presentation to user and transfer to a cloud-based server infrastructure for processing and storage [3]. Historical data can be accessed through a dedicated web application. A novelty of the system is the implementation of the "publish-subscribe" communication paradigm in air quality monitoring, enabling the users (citizens, city services, environmental and medical researchers etc.) to subscribe for real-time delivery of a personalized set of information of interest, such as data generated by a preferred sensor types within arbitrary, even movable, dynamically-changeable area of interest. This enables easy implementation of novel applications mentioned in introduction. Paradigm also enables sophisticated automated information trading among participating parties opening space for novel business models. By dynamic allocation of system resources, architecture promotes system-level energy efficiency. This maximizes sensors and smartphone battery life, and leads to optimized usage of cloud processing and storage resources.

Mobile air quality sensors constructed at University of Zagreb, are designed as a wireless, wearable smartphone accessory (Fig. 1). The initial version [4] contained low-cost MOX sensors, while in current version [5] they are equipped with a combination of two electrochemical sensors for measurement of atmospheric pollutant gas concentration: CO and NO_2, or SO_2. Also, microclimate parameters are measured: temperature, relative humidity and atmospheric pressure. On-board processing enables compensation of influential factors, and result output in physically correct units. Sensors are powered by a rechargeable battery. Special attention is put on energy efficient operation, enabling the autonomy of multiple days. Compact form-factor enables the sensors to be attached to clothes or on bicycles. Each sensor interfaces wirelessly to the smartphone using the Bluetooth connection. Geo-locational data is provided from smartphone's GPS.

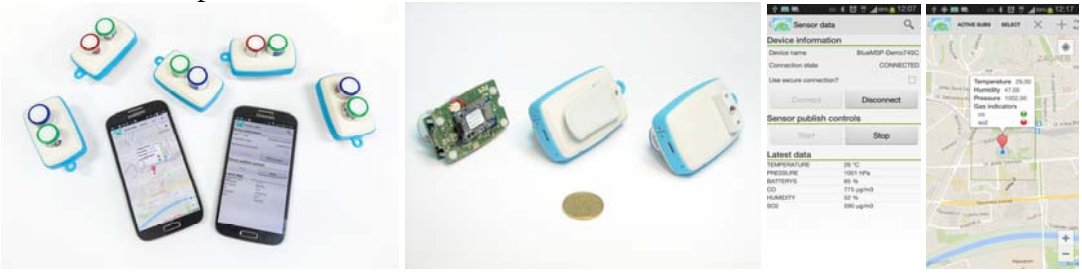

Figure 1. Left: FER Air Quality Sensors. Center: Electronic and mechanical design. Right: Smartphone application for data collection from sensor and real-time visualization.

Sensor accuracy was experimentally verified in a series of laboratory and outdoor experiments. Collocational calibration of CO and NO_2 sensors was conducted in cooperation with the Institute for Medical Research and Occupational Health, an accredited laboratory for measurement and validation of air quality data for the City of Zagreb, at one of their air quality monitoring stations. Results (Fig. 2) show that a good linear fit can be obtained with respect to referent gas analysers, with precision within tolerances for indicative measurements.

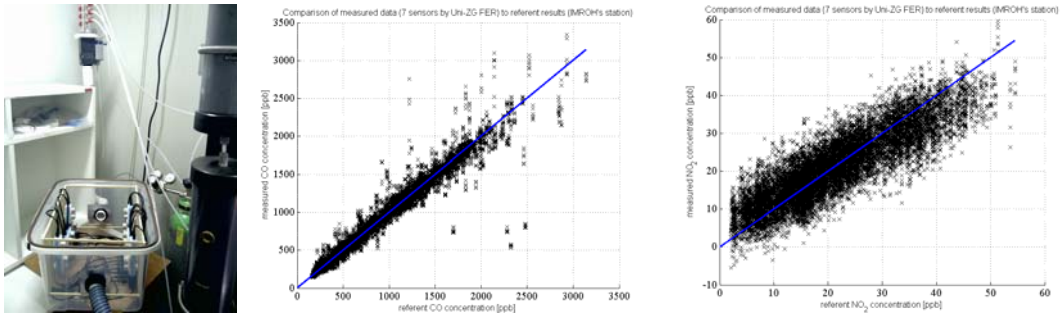

Figure 2. Collocational calibration. Left: measurement setup at IMROH. Center: accuracy of CO measurement. Right: results for NO_2.

System was functionally tested in a number of outdoor measurement campaigns: in Zagreb (July, 2014, and February, 2015), Split (September, 2014), Boston (October, 2014), and Karlsruhe (February, 2014). Experiments featured up to 20 pedestrians and bicycle riders simultaneously carrying sensors, Fig. 3. Results can be browsed at [6] and are available on request.

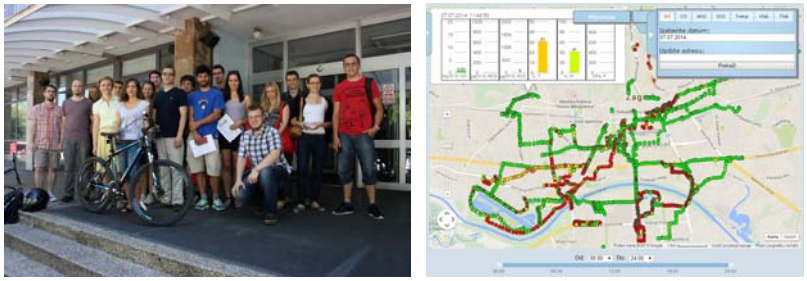

Figure 3. Participants and example results of outdoor experiments in Zagreb.

Our future work includes verification, and modelling of the effect of influential factors on electrochemical gas sensors (temperature, humidity), and methods/algorithms of maintaining in-field calibration during the run-time of the network of mobile gas sensors.

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ABSTRACTS OF POSTER PRESENTATIONS

Poster Presentation

CHARACTERIZATION OF ORGANIC MATTER IN MARINE AEROSOLS NEAR EUTROPHIC SEAWATER ECOSYSTEM (ROGOZNICA LAKE, CENTRAL DALMATIA) DURING WINTER SEASON

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In spite of decades of investigations, the effects of atmospheric aerosols via cloud formation and properties still constitutes the largest uncertainties in assessing the climate budget today [1]. These difficulties result in part from the limited understanding of the microphysical processes controlling the transformations of atmospheric aerosol particles into cloud droplets. Organic matter (OM) is an important atmospheric fraction which enters the atmosphere through biogenic emissions and anthropogenic sources. Many of the organics identified in the atmospheric aerosols are known to be surface active in aqueous solutions contributing to aerosol water soluble organic carbon (WSOC) pool [2]. Surface active substances (SAS) or surfactants become in focus of atmospheric research nowadays as they can substantially influence the surface tension of the gas-liquid interface of solution droplets in the air which plays a critical role in governing their cloud condensation nuclei (CCN) abilities. SAS as the most reactive part of natural organic matter are also enriched in the air-sea interface area known as the sea surface microlayer [3]. This millimetre thin layer represents widespread gelatinous and biofilm-like environment which exists even at higher than global average wind speeds. This created a new perspective of the air-water interface and its global role in exchanging marine OM with atmosphere. Thus, the impact of the SML on CCN formation through injection of surface active material from the SML to the atmosphere may be of global significance. A progressive approach to understanding the SML and hence its role in global biogeochemistry can only be achieved by considering all the key components of this complex environments an integrated whole. Thus combined interdisciplinary SML and aerosol study seems to be a promising approach to contributing to the knowledge on the linkage between the SML properties and cloud formation and climate.

We selected unique, highly eutrophic, euxinic marine lake system Rogoznica Lake in central Dalmatia (Middle Adriatic, 43°32'N 15°58'E) as one of the important study sites. Extreme and fluctuating environmental conditions affecting water column stratification related to salinity, temperature, redox conditions; mixing with high periodical supply of nutrient and sulphur species, indicate that the marine ecosystem Rogoznica Lake is extreme, naturally eutrophic system which feels all effects of the Adriatic atmospheric and ocean conditions. Influence of these conditions due to the lake semi-closed nature might be several times stronger than in other coastal and open sea Adriatic waters [4].

In order to get better insights into OM characteristics and dynamics between the atmosphere and the marine system this study is designed to comprise seasonal data of the marine aerosols as well as the SML and underlaying water samples (ULW, from 0.5 m depth) at the Rogoznica Lake. Here we will present first results of our winter (01-02 2015) campaign. The aerosol samples (aerodynamic diameter <2.5 μm) were collected on GF/F filters (φ=47 mm) by low volume sampler (2.3 m^3/h, sampling time: 24 h). The SML samples were collected by the Garrett screen method using the stainless steel screen Isolation and characterization of the water soluble organic matter (WSOM) from aerosol, SML and ULW

samples by determining the SAS using electrochemical techniques as well as determining the total organic carbon (TOC) and dissolved organic carbon (DOC) by high temperature catalytic oxidation (HTCO) technique were conducted.

Our preliminary results indicate that SMLs were enriched with TOC and SAS on average 6.6 and 2.1, respectively, if compared with ULW samples. The contribution of dissolved OC to the TOC pool was in range from 53 to 97% for the SML samples. Concentrations of the aerosol mass fluctuated from around 2.5 to 18.2 μg/m^3. The average concentration (5.5 μg/m^3) is comparable to the $PM_{2.5}$ values presented for several regional background sites in Europe. Organic matter represents, on average, approximately 3.8% of the aerosol mass. The average OC concentrations in this study are compared with those from other marine enviromnents over the world. To get more insight to the seasonal variability of predominant surfactant material in marine aerosols, obtained SAS concentrations (expressed in equivalent amounts of model surfactant T-X-100, mg/l) were normalized to the dissolved organic carbon content and corelated with normalized surfactant activities obtained for different model organic compounds as presented in Figure 1. Results will be discussed in relation to the previous data of different environmental systems, regions and seasons.

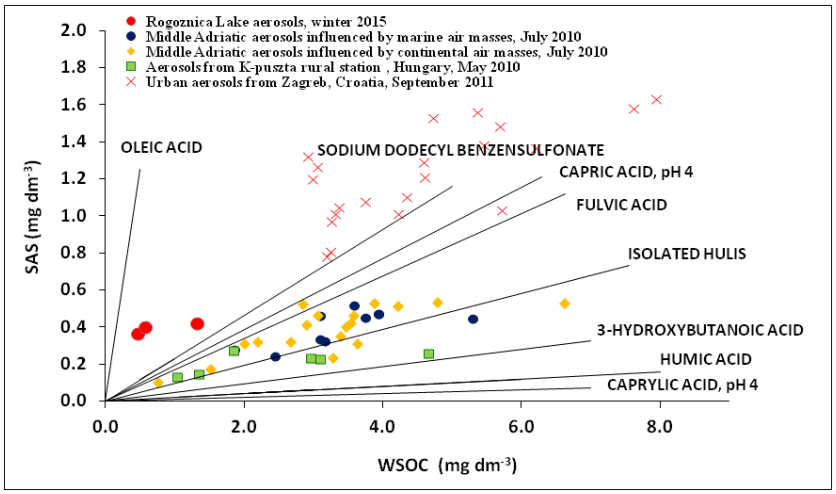

Figure 1. Correlation of SAS and WSOC concentrations of few winter aerosol samples colleted from Middle Adriatic (this study) with aerosols previously collected from different regions and seasons. The lines coresponds to isolated HULIS material and selected model substances as representatives for organics as WSOC in atmospheric precipitation.

Aknowledgement

This work was supported by nationally funded project "*The Sulphur and Carbon Dynamics in the Sea- and Fresh-water Environment (SPHERE) 1250*".

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Poster Presentation

IR LIDAR SENSING OF ATMOSPHERIC IMPURITIES VS. PASSIVE FTIR SPECTROSCOPY - A COMPARISON

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1. Passive FTIR Spectroscopy

The FTIR (Fourier-Transform Infrared) spectroscopy is a technique widely applied for detection and identification of gas impurities included in air of an open space. Advantages of remote FTIR measurements are the follows:

1) detection of polyatomic molecules
2) fast analysis of multicomponent mixtures
3) monitoring of gases emission from distance in real time
4) lack of contamination of sensor during measurements
5) easy service and low maintenance costs

Passive remote detection with the help of FTIR spectrometer allows detection and identification of contamination in atmosphere. It consists in the measurement of IR radiation, not of radiation made by artificial source. It results in mobility, velocity of measurements and the possibility of detection of contamination in the distance up to several kilometers.

Table 1. Scopes of the detection of the RAPID of Brüker [1]

Substance	**Concentration mg / m^3**	**X ppm**	*Parameters of measurement:*
Paralyzing (G)	3 - 5	0.4 - 0.8	Pressure: 1013 mbar Temperature: 298K Size of cloud: 100 m Temp. difference: 1K
Burning (HD, L)	6 - 9	0.7 - 1.0	
SF6 (simulator)	0.3	0.05	*Detection limits:* $xd\Delta T$ [ppm×m×K]
Ammonia	1.1	1.8	

Passive spectroscopy may be used for identification of dangerous industrial gases, observation of gas clouds, civil defense actions, intervention of fire brigade (chemical accidents, fires), remote detection of emission during airplane crashes, detection of military factors in combat conditions [2].

2. LIDAR atmosphere sensing

LIDAR (Light Detection and Ranging) belongs to the family of devices used for detection of specific gas substances and for determination of distance between objects and devices. It uses waves in the range from ultraviolet across visible light up to the infrared. The device consists

of emitter and receiver. The main part of the optical emitter of the device being concerned is a laser, which emits two appropriate light pulses in the spectral range of 9 - 11 μm. These pulses are dissipated in atmosphere by aerosol particles or molecules. A part of radiation is reversely dissipated and comes back to the LIDAR, where the receiver registers this signal. The typical feature of this device is using two non-coherent waves of different length (difference between length is very small and is in the range of several nanometers), which are called λ_{on} and λ_{off}. The λ_{on} must be fitted to the strong absorption line of specific gas substance, which is the atmospheric contamination, while the λ_{off} is the reference bundle. Laser emits short pulses of light with typical duration time of 20 ns, which compiles the spatial resolution ca. 3 m. Using elements of nonlinear optics it is possible to change the spectral range of detection into 4 - 5 μm wavelength. It also allows to detect such gases as CO (4.5 μm) and O_3 (4.7 μm) [3].

3. The comparison of passive FTIR spectroscopy and LIDAR supported by the pulse CO_2 laser

Both methods belong to the group, in which measurements are carried out without the necessity of entrance into the dangerous zone (red zone). The comparison of two ways of detection of atmospheric contamination is presented below.

Table 2. The comparison of two measurement methods.

Compared parameters	**FTIR passive spectroscopy**	**LIDAR with pulse CO_2 laser**
Measurement method	Passive	Active
Artificial light source	Lack	Laser CO_2 Infra-light
Measured property	Natural IR radiation	Backward scattering
Measurement range	700 - 1300 cm^{-1}	9.3 - 10.6 μm
Dependence of sensitivity of measurement	Temperature difference between background and source (min 1 K), cloud size, concentration of contamination	Type, size and shape of aerosol or molecule
Max distance from source	5 km	Dependant of laser power, from several m up to 15 km
Interference	Measurement masking by spectra of atmospheric substances e.g. steam or CO_2	Possibility of light dispersion by atmospheric phenomena e.g. rain

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Poster Presentation

Effects of Particle Indoor Air Pollution Concerning Smoking Habits

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Abstract

Indoor environment has some specific particularities, such as quasistable temperature and relative humidity regime, although managed but slow ventilation rate, which leads to limited dispersion of pollutants. One of the most important risk factor for indoor air quality in nowadays is related with smoking. Althouhg number of smokers (active and therefore passive) during last decade not changed, lung cancer cases have strong growing tendency; from about 1 billion smokers worldwide 80 % of them living in low- and middle-income countries, accordingly more people are having illnesses, which are related with respiratory system (lung cancer, asthma etc.) [1]. Some studies on smoking have shown, that people, who are exposed to passive smoking, are at higher risk (25 - 30 %) of developing coronary heart disease [2].

Cigarettes are products, which are made of tobacco and their smoke contains more than 4000 chemical substances (approximately 70 of them are carcinogenic), for example, carbon monoxide, formaldehyde. During smoking these substances changes both physically and chemically and increases passive smoking toxicity [3]. Smoke from cigarettes has two types: mainstream (inhaled by active smokers) and side-stream (inhaled by passive smokers). In countries, where index of smokers are high, almost everyone are exposed to influence of passive smoking.

During smoking air is polluted with aerosols (particulate matter), which is mixture of wide chemical spectra and size particles. Particles with aerodynamic diameter smaller than 2.5 mm are most hazardous, because of their ability to penetrate into a deeper parts of respiratory system [4].

The aim of the study was to identify aerosol fractional distribution depending on architectural varieties of kitchen, ventilation effectiveness during and after smoking. Different cigarettes were tested under various environmental conditions. Particulate matter measurements were done by using mobile optical counter (DT-9880). Particles were counted in following size channels: 0.3, 0.5, 1.0, 2.5, 5.0, 10.0 microns; four main cases within intervals of five minutes were investigated: (1) before smoking; (2) during smoking; (3) after smoking and (4) after smoking with opened window.

To detect changes after smoking in indoor environment, particulate matter was determined in the present case. It was revealed that the number of small particles (with aerodynamic diameter 0.3 - 0.5 microns) during smoking increases more than 5 times (see Fig. 1). Hazardous small particles are the most significant for respiratory system and tobacco burning process produces them in high levels. Even after smoking decrease of particulate matter is very slow, if there is no good availability of natural or mechanical ventilation.

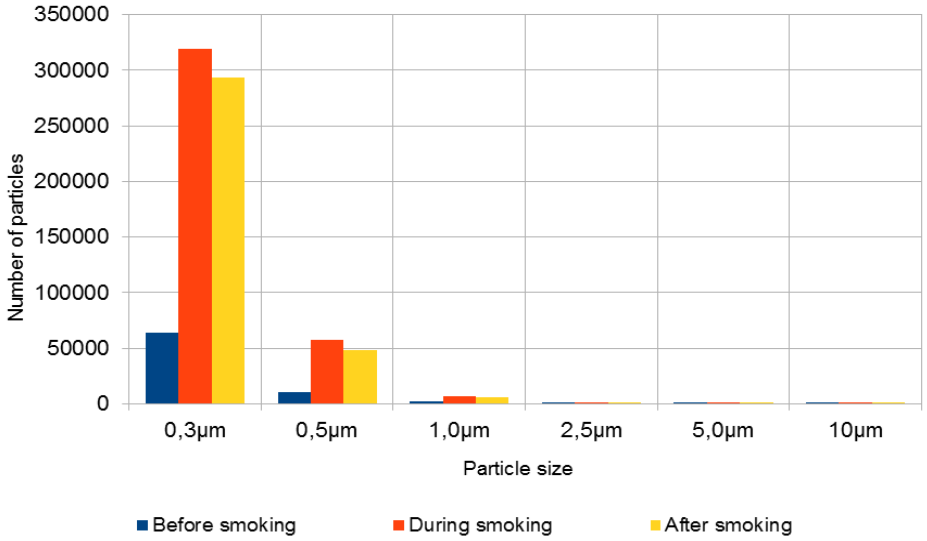

Figure 1. Comparison between particle size and number measurements before, during and after smoking

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Poster Presentation

ODOUR MEASUREMENTS USING COMMERCIAL USB-STICK SENSOR DEVICES

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Abstract
Odour is an important environmental pollution issue because it can affect public amenity and the community's quality of life. Attention to odour as an environmental nuisance has been growing as a result of increasing industrialization and the awareness of people's need for a clean environment. Efforts to abate odour levels are necessary in order to maintain the quality of the environment. Understanding the odour problem and the origin and dispersion of odours, abatement and detection methods are, therefore, very important aspects of odour pollution in the environment [1]. Odour air pollution is determined by wide spectra of different odorous substances and this kind of pollution is concentrated around sources and arise as a local scale problem. Unfortunately at European scale no unified regulations for odour air pollution assessment. According to existing Latvian legislation odour measurements should be done according to standard (reference method) LVS EN 13725:2004 "Air quality - Odour concentration assessment by dynamic olfactometry" or other comparable method. As knows olfaction method is very slow and expensive and there are a lot initiatives for other odour measurement methods.

In this study we used commercial USB-stick from JLM Innovation (http://www.jlm-innovation.de/) with Figaro (TGS 2602, TGS 2603) sensors. Above mentioned device is so-called micro hotplate metal-oxide sensor (MOS). Redox reactions occurring at the sensor surface resulting changes in resistance which is measured. The TGS 2602 sensor is highly sensitive to low concentrations of odorous gases, such as VOCs, hydrogen sulphide, ammonia. The TGS 2603 sensor is also sensitive, detecting gases - amines and gases containing sulphur.

Odour measurements in various places - urban street canyons, rural background, around oil processing company, inside cheese factory, sheep and cow farms. Measurements in street canyons were analyzed in line with conventional monitoring in order to prepare mathematical algorythms for measurement convertion from resistance level to concentration level. Additionally to sensor resistance measurements microclimatological measurements were done, such as temperature and relative humidity, as these parameters affecting result. First results from street canyon are given in Figure 1.

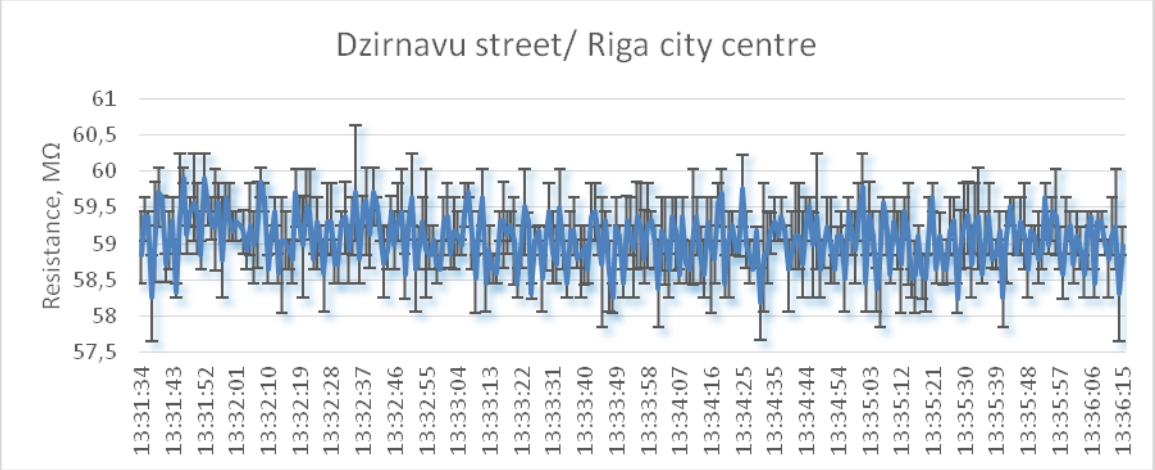

Figure 1. Electronic nose measurements in Riga city centre

Table 1. Particulate matter PM_{10} source apportionment modelling results in Riga.

No	Sector	Number of sources	Total amount of emissions, t/year	Maximum concentration, $\mu g/m^3$
1	Stationary point sources	454	241.0	17.5
2	Stationary area sources	115	2.3	26.4
3	Traffic	381	31.8	48.7
4	Households	245000	5.2	21.3
5	Background pollution	-	-	

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Poster Presentation

CHEMIRESISTIVE VOC SENSOR MATERIALS BASED ON SILICONE RUBBER COMPOSITES

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Abstract

At many places like factories, chemical waste dumps, underground storage tanks workers every day is exposed to volatile organic compounds (VOC). That is one of the reason why is needed accurate characterization and long-term monitoring to reduce health risks and ensure public safety. However, current detection methods, like gas chromatography, ion mobility spectrometry and quartz microbalance are costly and time-consuming [1]. There is need for inexpensive, low-powered, fast recovery and repeatable sensors, that's why different polymer matrix materials and fillers have been used to achieve these goals. Aim is to make polymer composite-absorption based sensor that indicates a change in relative electrical resistance when exposed to (VOC). Silicone rubber has been chosen as matrix material, because it has better weathering and aging resistance, and chemical stability comparing to ordinary organic rubbers.

Highly structured carbon black (CB) and short multiwall carbon nano-tubes have been used as filler material in the composite. Homogenous composite mixture of nanofiller and silicone rubber was coated on crystalline glass-ceramic substrate with aluminum electrodes by dip coating method. Composites were cross-linked by changing vulcanization pressure. Crosslinking time, temperature and atmosphere were maintained constant. Inert gas, nitrogen, atmosphere was chosen to reduce the possibility of peroxide to inhibit. During crosslinking the composite electrical resistance was measured as indicator of composite system electric network formation.

It was found out that the composite steady state electrical resistance significantly reduces, when temperature (~ 180^{o}C) and pressure is applied. Silicone composite viscosity during vulcanization reduces. These are favorable conditions for filler aggregates to rearrange and form conductive network. Electric resistance stabilization at the end of crosslinking approves composite system electric network formation. Experiments carried out shows that pressure applied during vulcanization changes the sample steady state electric resistance after curing.

After curing the Fourier transform infrared spectroscopy (FTIR) was used to evaluate chemical bond changes, which could approve that crosslinking reactions are completed. Using FTIR chemical bond changes was measured. Fluctuations that are inherent polydimethylsiloxane, like -Si-$(CH_3)_2$ (1260; 865-750 cm^{-1}), Si-O-Si (1130-1000 cm^{-1}) and others has been detected. Absorbance of various chemical bonds changes when during crosslinking applied pressure is changed. Applying higher pressure, absorbance of chemical bonds that approve that crosslinking reactions has been completed, like $CH=CH_2$ (1410 cm^{-1}) stretching, reduces. Silicone reaction with nitrogen atmosphere also has been shown in the spectrum. N=O (1460-1440 cm^{-1}) bond shows that crosslinking reaction probably are not fully completed, because part of peroxide has been neutralized by nitrogen [2].

Relative electrical resistance change of silicon rubber composites was measured, when the composite samples were exposed to different concentrations of non-polar toluene vapours. Nitrogen as carrier gas was used during all experiment time. Fast recovery of the composite electrical resistance has been noticed, when the composite are not in contact with toluene.

Figure 1 shows that the sample containing CNT relative electrical resistance is twice larger than CB. Grate advantage for silicone composites is fast recovery of electrical resistance when the composite are not in contact with toluene. Recovery speed remains also at different concentration of toluene.

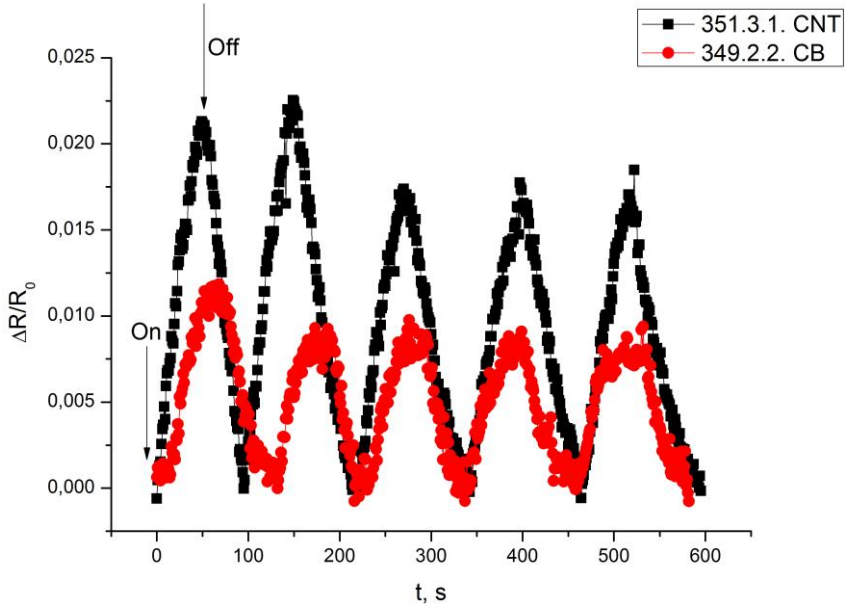

Figure 1. Relative electrical resistance change of silicon rubber composites in non-polar toluene vapours (800 ppm) containing short multiwall carbon nanotubes (CNT) and 349.2.2. highly structured nanocarbon black (CB).

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Poster Presentation

ETHYLENE VINYLACETATE COPOLYMER AND NANOGRAPHITE PARTICLE COMPOSITE AS VOC SENSOR

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Introduction

One of the reasons for pollution is the great number of chemicals around us. Chemicals which can harm human health are everywhere in our life's, especially in manufacturing, where they are manufacturing products or by-products. Because of lack of mobile and accurate VOC sensing device workers of manufacture and in some cases even local citizens are exposed to high concentration of VOC.

For example toluene is used widely in the manufacture of polymers for plastic bottles and to make polyurethane and nylon, in the manufacture of cosmetics and in the manufacture of dyes and inks. Also toluene can be used as a fuel additive where it is used to increase the octane ratings and as a solvent in cleaning agents, adhesives, resins, paints and paint thinners. But OSHA (Occupational Safety & Health Administration) permissible exposure limit (PEL) for toluene in general industry is 200ppm that can cause central nervous system depression, causing fatigue, headache, confusion, paresthesia, dizziness, and muscular incoordination. But only 10 minutes in 500 ppm of toluene vapours can cause irritation of the eyes, mucous membranes, and target upper respiratory tract [1].

For this reason ethylene vinylacetate copolymer and nanographite particle composite was made in order to develop VOC sensor. With the term "nanographite" can be marked following fillers: extra-conductive highly structured carbon black (EHSCB), carbon nanotubes (CNT), thermally exfoliated graphite (TEG) as well as recently discovered graphene because all of them have a sp2-hybridized crystal structure like graphite, but at least one dimension of nanographite is smaller than 100 nm. In this research we used EHSCB as composite filler. Their primary nanoparticles are made of graphite platelets and therefore are extra-conductive.

Materials and methods

Ethylene vinyl acetate copolymer (Sigma Aldrich) was used as polymer matrix for the composite. From previous studies [2-3] it is cleared that amount of vinyl acetate in copolymer significantly affect its crystallization degree and flexibility, for that reason we used ethylene vinylacetate copolymer with 40 % vinylacetate content. Copolymer consists of ethylene and vinylacetate repeating units, where ethylene unit is non-polar and vinylacetate - polar. Copolymer complex structure indicates that the acquired composite material sensor could detect both polar and non-polar organic solvent vapours.

Nanographite particles (EHSCB: PRINTEX XE-2; CB) with average particle size 30 nm were used as conductive filler for first type of composites. Particles specific surface: 950 m^2/g and DBP (dibutyl phthalate) adsorption: 380 ml/100 g. PRINTEX XE-2 as mentioned before has high electrical and it has been used in many electrical rubber creation.

Composite was made by dissolution method were dissolved composite solution was obtained. Afterwards epoxy laminate plate with coper electrodes were coated with composite solution using dip-coating method.

Results and discussion

There were made various experiments that show EVA-CB ability to detect toluene in low concentrations. In figure 1 is shown relative electrical resistance change versus time in two concentrations of toluene vapours.

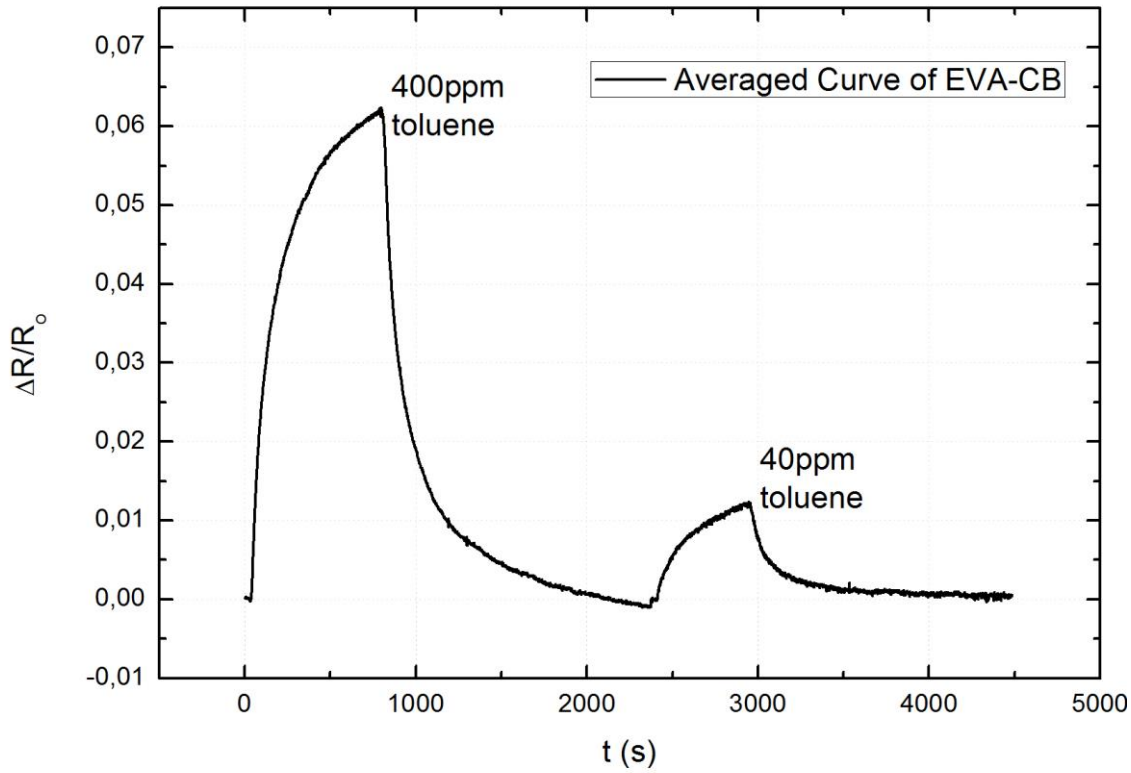

Figure 1. Relative electrical resistance change versus time in two concentrations of toluene vapours.

Results show that EVA-CB is able to detect toluene vapours at low concentrations and can detect differences in concentrations. Also there were made EVA-CB experiments in more polar vapours - ethanol. Results show different reactions on ethanol and toluene vapours at the same concentration. It can be explainable with EVA complicated structure, it's polar and nonpolar parts.

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Poster Presentation

INTEGRATION AND PERFORMANCE OF AN ULTRA-LOW POWER PALLADIUM-BASED MEMS HYDROGEN SENSOR FOR HIGH SELECTIVE MONITORING AND FAST DETECTION

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Abstract
Nowadays, hydrogen (H_2) is increasingly used for many applications such as fossil fuel processing and ammonia production in both petroleum and chemical industries, coolant in power station or pollutant-free energy carrier in fuel cell. As H_2 is flammable or explosive at concentrations between 4 and 75 % in air, its fast detection is essential to ensure safety. Because it features reversible absorption of H_2, Pd is often used as active material in H_2 solid-state sensors, including catalytic, thermal or semiconducting metal-oxide. Though, these sensors still show high response time above 10 s, high power consumption of typically more than 100 mW and poor selectivity, depending on the transduction mechanism [1]. Looking for higher safety, automotive and chemical industries are today looking for low-cost, low-power, fast and selective H_2 sensors, with measuring range up to the LEL and detection limit below 100 ppm [1]. Recently, researches focused on Pd-coated cantilever and Pd-based MEMS resonant devices with increased sensitivity and low response time, together with high selectivity [2].

In order to further reduce power consumption while maintaining high dynamics and selectivity, the development of a MEMS-based capacitive transducer has been reported in [3]. The sensing mechanism is based on the actuation of double-clamped Al beams by a Pd/Al bimorph on a quarter of their length. Pd-hydriding induces internal compressive stress with a specific kinematic depending on the initial tensile stress in the structure, as detailed in Figure 1.

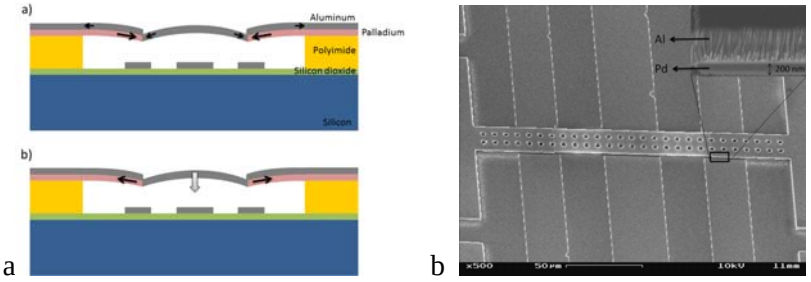

Figure 1. a. Schematic cross-section of the working MEMS transducer: a) Initial state, b) Membrane deflection due to compressive stress induced by H_2 in the Pd thin film. b. SEM picture of the MEMS transducer.

The recent developments focus on both system integration and packaging for compliance with industry standards. As depicted in Figure 2, the MEMS transducer is encapsulated in a TO-5 package and interfaced with an AD774x capacitance-to-digital converter. A CC253x microcontroller is used for data processing and sensor calibration. The electronic interface is schematized in Figure 2. Analog or digital outputs with SPI or I2C data link modes are implemented. As capacitive sensors are moisture sensitive, a Porex® microporous membrane is integrated inside the cover of the 4-Series compatible housing and acts as humidity and small particles filter. Finally, in order to be compliant with ATEX directive, the sensor is placed in an explosion-proof case with sintered metal filter.

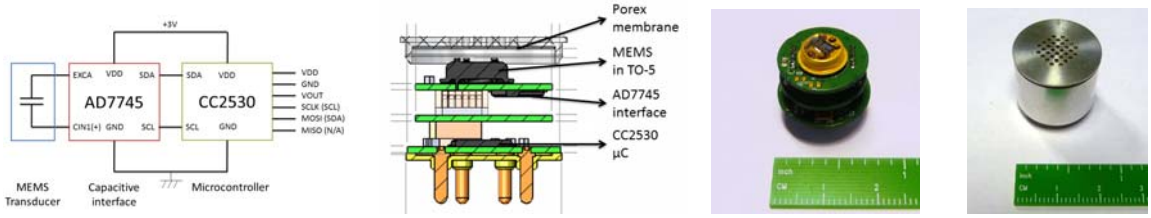

Figure 2. Electronic diagram, schematic cross-section and pictures of the MEMS sensor integration in a 4-Series compatible housing.

Characterizations have been performed in both air and N_2 atmosphere. The sensor responses to 2 % H_2 in air and at several H_2 concentrations in N_2 are shown in Figure 3. In order to analyze the full system dynamic, the response times of each sub-component are analyzed, as detailed in Table 1. The Porex® membrane induces a 2 s diffusion time, which is similar to those of the housing and the transducer itself. The filter protects the sensor to moisture up to 95 %RH at 45 °C, or about 60 g/m^3 absolute by monitoring the humidity inside the housing and using an ESPEC SH-261 humidity chamber.

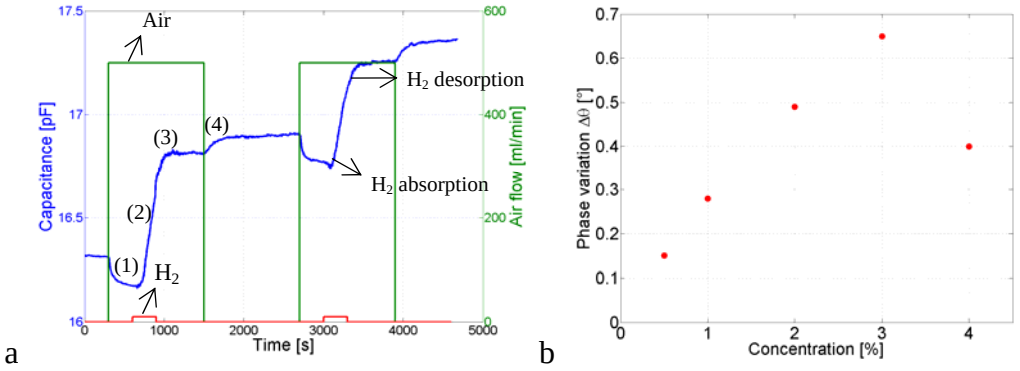

Figure 3. a. Capacitance variation in 2% H_2/dry air mixture. The drift is caused by the plastic deformation induced by the stress due to the Pd-hydriding. The initial response to dry air flow is due to the forced humidity desorption of the polymer. b. Maximal phase variation after 5 minutes exposure at 0.5%, 1%, 2%, 3% and 4% H_2 using N_2 carrier gas [3].

Table 1. Response times of each sub-system components at 0.2 % H2 in dry air.

Component	**Response time [s]**	**Total time [s]**
Housing diffusion holes grid	2.8	2.8
Porex® membrane	2	4.8
Sintered-metal filter	0.8	5.6
MEMS transducer	3	8.6

The power consumption of the system is currently about 10 mW in continuous mode. It is envisioned to reduce it below 100 µW by using dedicated interface and microcontroller. Such device is very promising for future low cost and ultra-low power sensing applications, for higher safety in the so-called hydrogen society.

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Poster Presentation

OPTICAL AIR QUALITY SENSORS: BENZENE, DUST, CO_2

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Benzene detection

Benzene detection is a challenging because benzene is already toxic at low concentrations and permitted limit is 1 ppm ~ 3 µl/m^3. Benzene is used in gasoline and solvents as well as it is emitted with smoke. We explore possibility to detect benzene in air using UV absorption spectroscopy and mercury emission line at 254 nm. Benzene spectrum has absorption feature at 254 nm. We recently demonstrated [1] that it is possible to use a commercial portable Zeeman atomic absorption mercury spectrometer *Lumex RA 915+* for measuring benzene in air, see Fig.1.

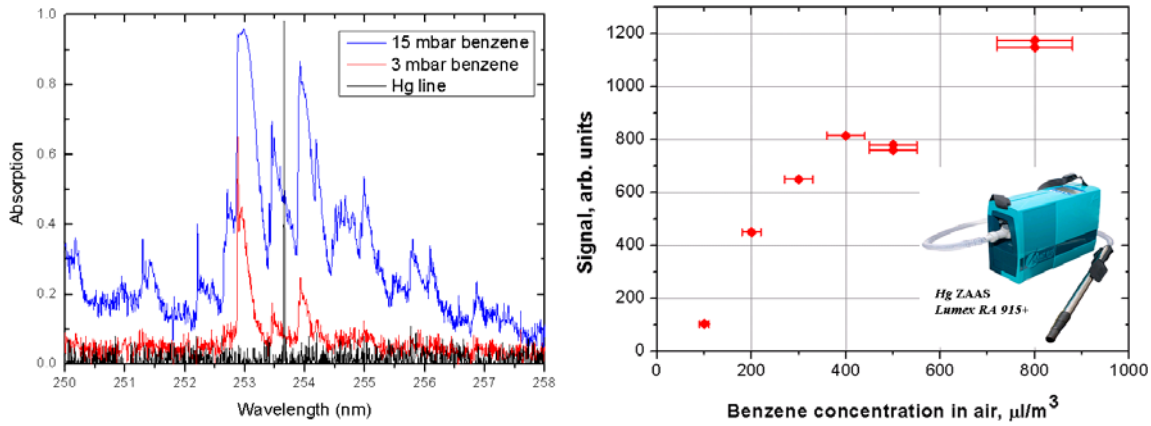

Figure 1. Left: Recorded UV absorption spectra of benzene vapour and atomic emission line from mercury. Right: Measuring benzene in air with a commercial mercury Zeeman atomic absorption spectrometer.

NDIR CO2 sensor

CO2 is a greenhouse gas and it's concentration has been increasing during last 50 years of monitoring from 300 to 400 ppm. CO_2 content in exhaled air is about 100 times larger 4%. Elevated CO2 concentrations in air are responsible for tiredness and is a problem in many school and university lecture halls. CO_2 sensor could help to save energy by optimizing automatic ventilation. We have compared electrochemical CO_2 sensor *MQ135* with a commercial non-dispersive infrared (NDIR) [2] CO_2 sensor *Extech CO100*. Electrochemical sensor needs long warm-up time and is influenced by ambient temperature changes. NDIR CO2 analyser is more precise, specified uncertainty is 75 ppm. Using a Wi-Fi adapter board *ESP8266* we have connected the *Extech CO100* sensor to Internet cloud service *Xively.com* for storage and live graphing of data, see Fig. 2.

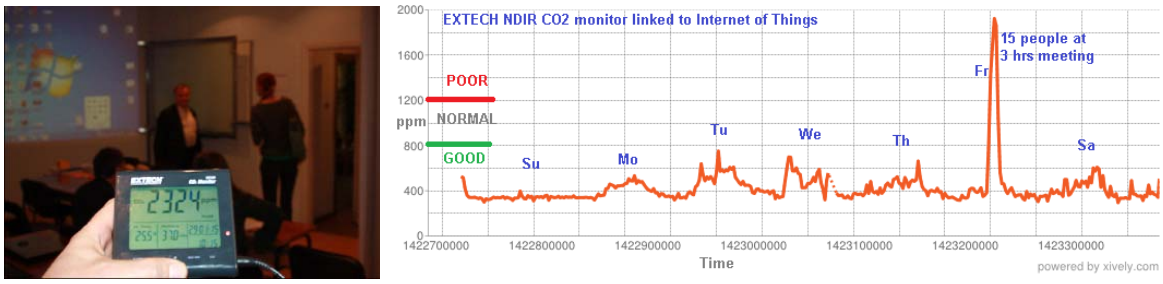

Figure 2. Left: NDIR CO2 monitor *Extech CO100*. Right: One week of monitoring CO2 level in office and during a meeting.

Dust sensor

We have constructed airborne dust sensor based on 1 W blue 455 nm diode laser and a photodetector allowing to count light flashes scattered by dust. In the city air we count up to 50 particles/cm^3 (50 million/m^3). Our design is similar to [3] but by using a blue laser we are more sensitive to small dust. We needed to monitor air in the laser laboratory, where dust causes decrease of laser power. Fine dust originates from car tires, diesel engines, heating chimneys, pollen, construction, etc. Particles in the range 1 - 10 μm can penetrate deep into lung alveoli and can cause asthma and lung cancer. We have installed air filter and see that consumer grade filter stops 90 % of dust by mass, but only roughly 1 % by count and the fine dust can be stopped only using HEPA grade air filters.

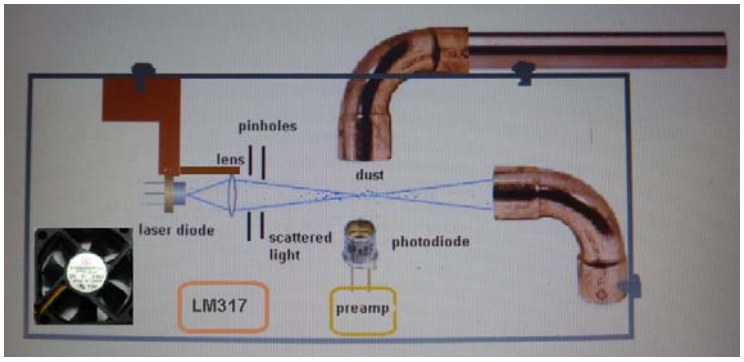

Figure 3. Home-made laser-based airborne dust sensor.

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Poster Presentation

GAS SENSORS BASED ON PLD-MODIFIED GRAPHENE FOR ENVIRONMENTAL MONITORING

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Motivation

Graphene-based gas sensors have been demonstrated to be extremely sensitive to major pollutant gases when detected in inert atmospheres [1,2]. Recently, high sensitivity to NO_2 gas was shown also in air with epitaxial [3,4], ozone-treated [5], or perforated graphene [6]. Still, for exploiting the full potential of graphene as a base material for versatile and cost-effective gas sensors, new approaches are required for not only increasing the sensitivity but also making the devices (partially) selective. Functionalization is an essential step in such development and diversification of graphene based gas sensors. In the present work, we demonstrate the functionalization of single layer graphene by pulsed laser deposition (PLD) and its impact on the sensitivity of NO_2 gas in case of different deposited materials.

Results

We used lab-grown CVD graphene, transferred onto Si/SiO_2 substrates pre-patterned with Ti/Au electrodes. These structures were functionalized in the PLD chamber by using different deposition targets (ZrO_2, TiN, and Ag) ablated by KrF excimer laser. The process was carried out in oxygen or nitrogen gas at 10^{-3} - 10^{-2} mbar. Note that PLD can be used as an extremely precise tailoring tool for the modification of graphene properties as typically only ~1/100th of a monolayer is deposited by a single laser pulse.

The functionalized samples were characterized by Raman spectroscopy, electrical conductivity measurements, and scanning electron microscopy. In all samples, the D-band was initially absent in the Raman spectra but it appeared and rapidly increased already at the small amounts of deposited material (~10 laser pulses). At the later stages (up to 1000 laser pulses), the I_D/I_G ratio in the Raman spectra approached 2. At the same conditions, the conductance of the samples decreased gradually up to one order and the gas response (relative change of conductance) increased even more (see figure 1).

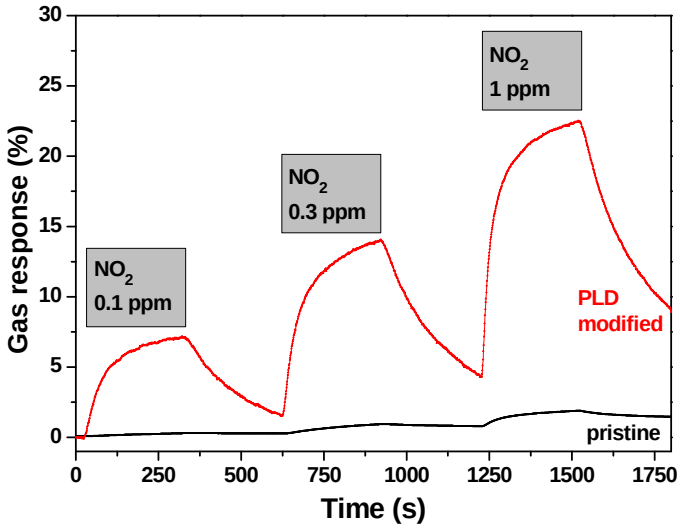

Figure 1. Responses of the pristine graphene sensor and the sensor modified by 250 PLD pulses of ZrO_2 to NO_2 gas in dry air. The samples were illuminated by 365 nm light during measurements.

The gas responses depended on the type of PLD target material. In case of ZrO_2 especially large increase of sensitivity occurred only when UV (365 nm) light was used during the gas response measurements. In case of TiN even the larger gain in sensitivity was obtained and UV light was only required for restoring the signal after NO_2 exposure. After deposition of Ag the signal started to recover even without UV exposure.

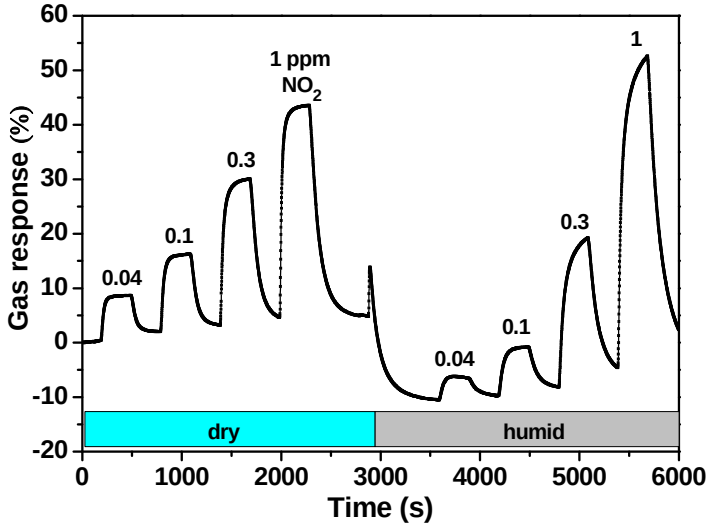

Figure 2. Responses of the graphene sensor with deposited TiN (415 laser pulses) to NO_2 gas in air. The relative humidities are 0% and 50% for dry and humid conditions, respectively.

The ultimate level of detection, as extrapolated from the data in figure 2, is below 1 ppb. Hence the practical range of measurement for environmental monitoring (~1-100 ppb) can be well covered.

As a general consequence, we believe that the method demonstrated in this work can be used for creating different types of adsorption centres by using different target materials and deposition conditions, and hence the new sensor structures can be created for the sensitive and (partially) selective detection of other gases as well.

Acknowledgment

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Poster Presentation

SPINEL FERRITE GAS SENSORS

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Abstract

Spinel ferrites are highly important electronic materials for more than half a century and offer a suitable ceramic base to move into this market given the simplicity and low cost, and are set apart from other gas sensors with a structural and compositional versatility. Our recent work highlights the developments and reflects the impact of the spinel ferrites on gas sensor technology [1-4]. The sensing mechanisms are explained for n-type, p-type, mixed and doped spinel ferrite gas sensors detecting a range of gases. The change in conduction mechanism is discussed with electronic sensitization. It is explained how some change in stoichiometry of spinel ferrite compounds will support a change in oxidation state and therefore increase the gas response. Spinel type ferrites are very versatile gas sensing materials that with continued development show greater application for industrial applications. Ferrites can offer high gas response and stability (Figure 1).

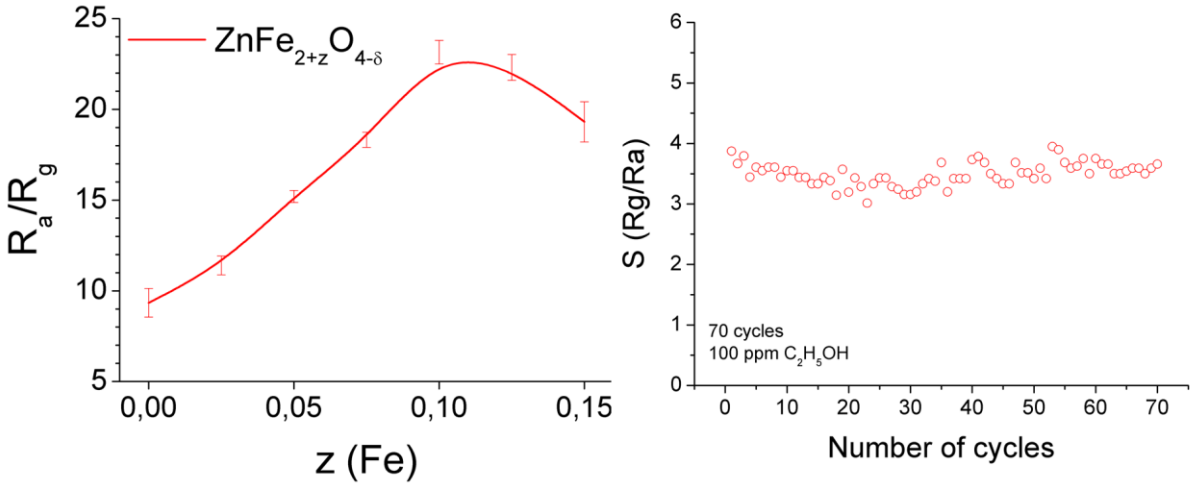

Figure 1. Gas response for zinc ferrite with different iron stoichiometry towards ethanol 500 ppm (left) and response-recovery behavior for $ZnFe_2O_4$ over 70 cycles (right).

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Poster Presentation

PRACTICAL APPLICATION OF COMMERCIAL ALPHA-MOS E-NOSE FOR AIR QUALITY CONTROL IN RIGA

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SIA Estonian, Latvian & Lithuanian Environment

Abstract

The historic location of Riga Free Port in the close proximity to the city centre and densely population living areas has several environmental implications, one of which is the high risk of odour nuisance. This is particularly topical issues in case of port terminals dealing with unloading, short-term storage and loading of heavy fuel oils and crude oil with changing compositions and varying contents of fetid elements. In addition until recently incompleteness of Latvian legislation in a field of odour nuisance led to a series of unresolved issues between the operators, state environmental institutions and local citizens.

After a long period of dealing with citizens' complaints, warnings from the state environmental inspectorate and planning for the future expansion, one particular oil product terminal of Riga Free Port expressed interest in finding a long-term solution to the problem of odour monitoring and communication with the state environmental institutions and citizens. The proposed and accepted solution was introduction of the Alpha M.O.S. continuous e-nose odour monitoring system, the first of its kind in the Baltic region.

The aim of the project was to develop a system for collection and communication of the odour monitoring data that would a) serve as an alternative to the single or regular olfactometry measurements, which are only possible at certain periods of time and do not provide a full picture or prove the objectiveness of particular public complains, b) provide opportunity for the operator to demonstrate their own contribution to the total level of odour nuisance compared to other odour sources in the impact area, c) serve as a management, operational and odour control tool, and d) facilitate communication between the operator, state environmental institutions and general public.

The developed system consists of two main elements, i.e. Alpha M.O.S. odour monitoring tools and specially developed web-access interface presenting the real-time and historic odour levels. The hardware of the system consists of 3 monitoring sites equipped with RQ Box devices. RQ Box is a gas analyser designed to measure volatile organic molecules by a global approach. Each device is equipped with PID sensor, electrochemical cells and MOS sensors; the combination of sensors is selected specifically for each monitoring site based on the main odour substances present in the impact area. The equipment goes through the calibration stage, during which instruments are "trained" to recognise certain gas combinations and concentration as odour and express concentration in odour units (OU/m^3). The system is supplemented by the on-site meteorological station.

Data collected from the monitoring devices is transmitted to the web server via GPRS. This data can be easily accessed and visualised using the specially developed web platform, which provides data on location of the monitoring devices, odour concentrations and meteorological data in a user-friendly interface.

The system has been installed in July 2014 followed by the observation phase during which the general analysis of the monitoring data was performed to access the correlation between monitoring results and operations on site. Observation phase was followed by the calibration phase, during which odour study according to EN 13725 methodology was performed. The data collected during the study was than fed into to the software used to calculate the model which interprets sensor data into odour units suited to the site. This model was then integrated into the analyser control software, and the RQ Box entered the routine phase.

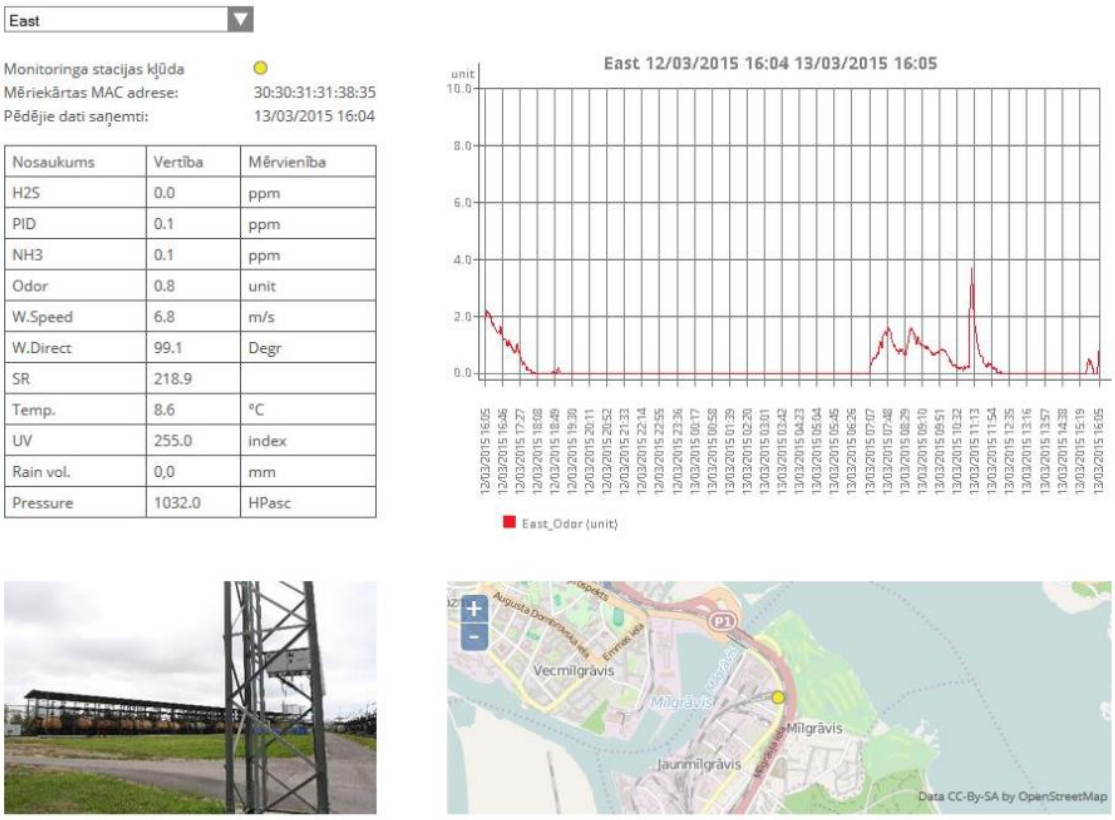

Figure 1. View of the web application.

It is argued that effective communication between operator, environmental institutions and general public is essential to the successful odour management [1]. The experience of application of Alpha M.O.S. continued odour monitoring system in one of the terminals of Riga Free Port demonstrates large potential such systems have in facilitation of communication between the stakeholders and improved odour management in general. The system allows for analysis of long- and short-term monitoring data, investigation of meteorological conditions and potential sources of odour, effective operational management aimed at reduction of odour nuisance, as well as provides a useful tool for communication with the relevant stakeholders through the potential provision of open access to the monitoring data via user-friendly web-interface to general public and responsible authorities.

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Poster Presentation

ONE-DIMENSIONAL ZNO NANOSTRUCTURES AND THEIR OPTOELECTRONIC APPLICATIONS

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Abstract

One-dimensional (1D) ZnO nanostructures, and more specifically nanorods (NRs), have attracted an increasing interest in recent years due to their potential in optoelectronic applications [1]. To fully exploit this potential, several problems, such as understanding and controlling Schottky contact on nanostructured ZnO or difficulty in obtaining reliable and controllable p-type ZnO, must be overcome. Preparation of high quality rectifying Schottky contacts on ZnO is a complex task; crystal defects, residual impurities, surface asperities, and chemical reactions forming oxides and eutectics all have a large impact on the formation of a Schottky contact [2]. Recently, we have demonstrated that colloidal graphite deposited by simple drop casting technique forms a Schottky contact on both nanostructured and bulk ZnO [3,4]. The current transport of the graphite/bulk ZnO junction is dominated by thermionic emission at room temperature and above [3]. The transport mechanism of the graphite/ZnO NRs junction can be described by a tunnel-recombination current transport mechanism via interface states [4].

Arrays of vertically well aligned ZnO NRs were prepared on nanostructured ZnO films using a low temperature hydrothermal method [4]. Use of the low cost, environmentally friendly electrophoretic deposition technique (EPD) as seeding procedureallowed us to obtain homogeneous, well oriented nanostructured ZnO thin films [5]. The crystalline analysis by x-ray diffraction (XRD) showed the highest peak at 34.44°, which corresponds to the (002) plane, thus confirming that the growth of the ZnO NRs takes place along the c-axis [6]. The 4 K photoluminescence spectra of the ZnO NRs showed a weak bound exciton line at 3.363 eV and a broad band with maximum at 2.0 eV. The line at 3.22 eV in the near bang-gap spectrum is associated with shallow donor-shallow acceptor transitions. Nitrogen is the most likely shallow acceptor due to the presence of nitrogen compounds in the growth solution [4]. Schottky contact was prepared by the deposition of colloidal graphite on top of a hydrothermally grown ZnO nanorods array by simple and low-cost drop-casting technique (Fig. 1a).

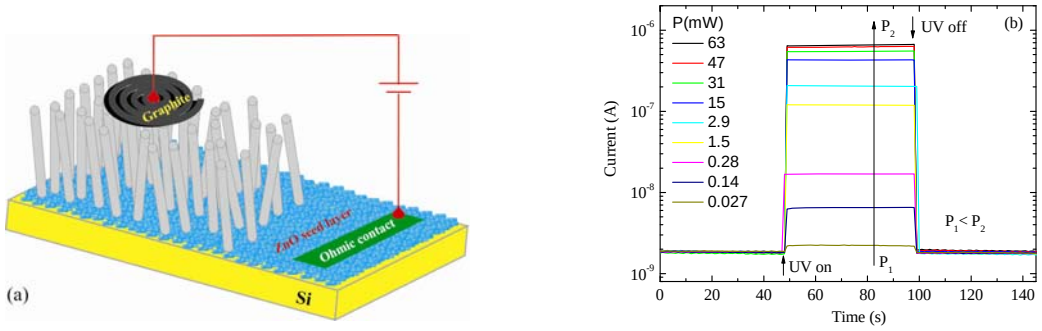

Figure 1. (a) Schematic cross section of the graphite/ZnO NRs junction; (b) Photoresponse under various UV illumination (395 nm) intensities at a reverse bias of 1mV.

The graphite/ZnO NRs junction can be used in UV photodetectors [6]; the photodetector is highly sensitive in a wide range of UV illumination intensities (Fig. 1b).

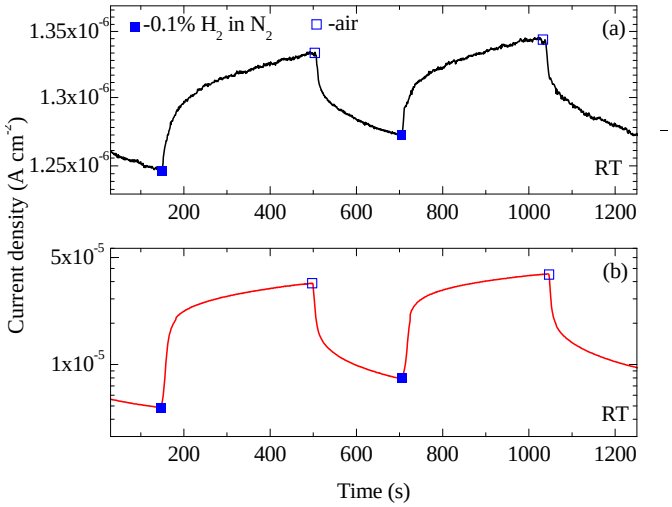

Figure 2. Current transient characteristics of the graphite/ZnO NRs junction (a) and graphite-Pt NPs/ZnO NRs junction (b) measured at -0.1V.

We have recently demonstrated that the graphite/ZnO NRs junction shows response to hydrogen even at room temperature [4]. To improve sensitivity of the hydrogen sensors, we decorated ZnO NRs with Pt nanoparticles (NPs). The Pt NPs dispersed in isooctane solution were prepared by reverse micelle technique [7] and then electrophoretically deposited onto ZnO NRs. The uncoated device showed sensitivity ~7% at 1000 ppm of H_2 in N_2. Decoration of ZnO NRs with Pt NPs increases the sensing response 100 times compared with the structures with bare ZnO NRs (Fig. 2).

This work was supported by EU COST Action TD1105 - project LD14111 of the Ministry of Education CR and by the Czech Science Foundation project 15-17044S.

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Poster Presentation

MICRO/NANOMECHANICAL ELEMENTS STUDIED BY LASER PHOTOACOUSTIC SPECTROSCOPY FOR THE DEVELOPMENT OF NEW SENSING THECNOLOGIES

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Abstract

Laser Photoacoustic Absorption Spectroscopy (PAS) is a highly specific and sensitive detection method. In PAS, the laser radiation is absorbed by a gas in a cuvette and subsequently converted to heat, which leads to the gas expansion. If the laser radiation is chopped or modulated, pressure waves emerging in the cuvette can be sensed by a microphone. By increasing the sensitivity of the microphone, the powerful expensive laser source could be replaced by a much cheaper IR diode laser source or a thermal radiation source. To increase the sensitivity of this method, Kauppinen et. al. [1] have proposed an optical microphone instead of the conventional one. The movement of a membrane - silicon cantilever, is sensed via a laser beam reflected onto a position sensitive detector.

In our previous work [2], we have developed a method for the investigation of micro/nanomechanical elements that could serve as sensitive membranes in the optical microphone. These elements have the potential to further enhance the sensitivity of PAS method. Our method utilizes a photoacoustic cell equipped with a microphone as well as a place for mounting the investigated elements. A discretely tunable CO_2 laser was used as the source of radiation energy for the laser PAS experiments (Figure 1). Sensitivity testing of the investigated sensing elements was performed with the aid of concentration standards and a mixing arrangement in a flow regime. The combination of sensitive microphones and micromechanical/nanomechanical elements with laser techniques offers a method for the study and development of new, reliable and highly sensitive chemical sensing systems.

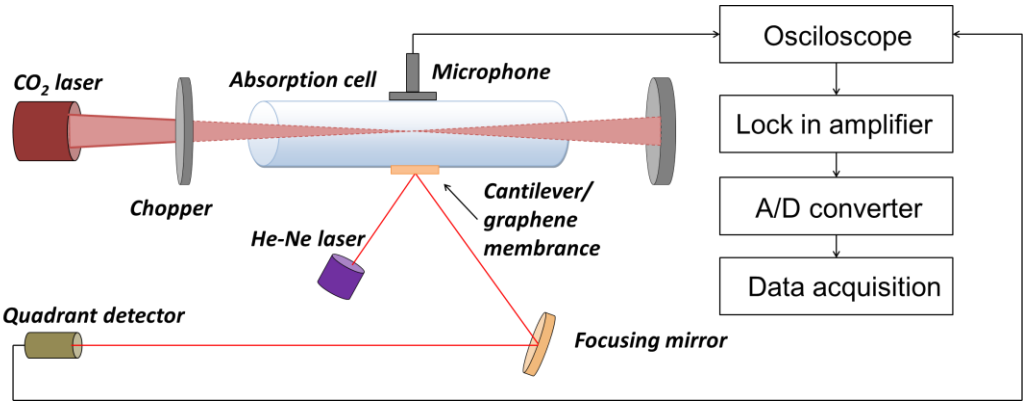

Figure 1: Experimental setup of the developed method

The developed method was then used for testing of two types of home-made sensing elements: four coupled silicon micro-levers and a multilayer graphene membrane. The sensitivity of these elements was inferior to that of the commercial electret microphone (with

an S/N ratio that is 5 times lower), but further improvement is expected to be achieved by adjusting the micro-levers and membrane elements, the photoacoustic system and the position detector.

In this work, new sensing elements Multi-Layer Graphene (MLG membranes) were prepared according to slightly modified method [2] using different technique of attaching membrane to glass window. Use of pre-hardened epoxy glue led to membranes with lower stiffness and thus to better sensitivity of these elements. Further, we have studied the influence of surface metallization and construction changes on the sensitivity of these elements. All elements had similar thickness (~10^2 nm). We have assumed that metalized membrane could better reflect laser beam and so enhance the detection sensitivity. Actually Platinum metallized (~70 nm) membrane has not shown better sensitivity than the plain membrane. It seems that metallization of membrane surface leads to dispersion of He-Ne laser beam. Insertion of pressure-balancing channel to glass window should reduce damping of membrane which decreases sensitivity. However any significant effect was not observed. We have also tested the influence of the photoacoustic arrangement by changing the length of the PA cell.

Acknowledgement:
The authors are grateful for the financial support via the project no. LD14022 within the COST Action TD 1105 funded by the MEYS CR and via the project No. 14-14696S funded by the Grant Agency of the Czech Republic.

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Riga (Latvia), 26 - 27 March 2015

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Local organizer:

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University of Latvia
Alberta Street 10-307, Riga (Latvia), LV1010
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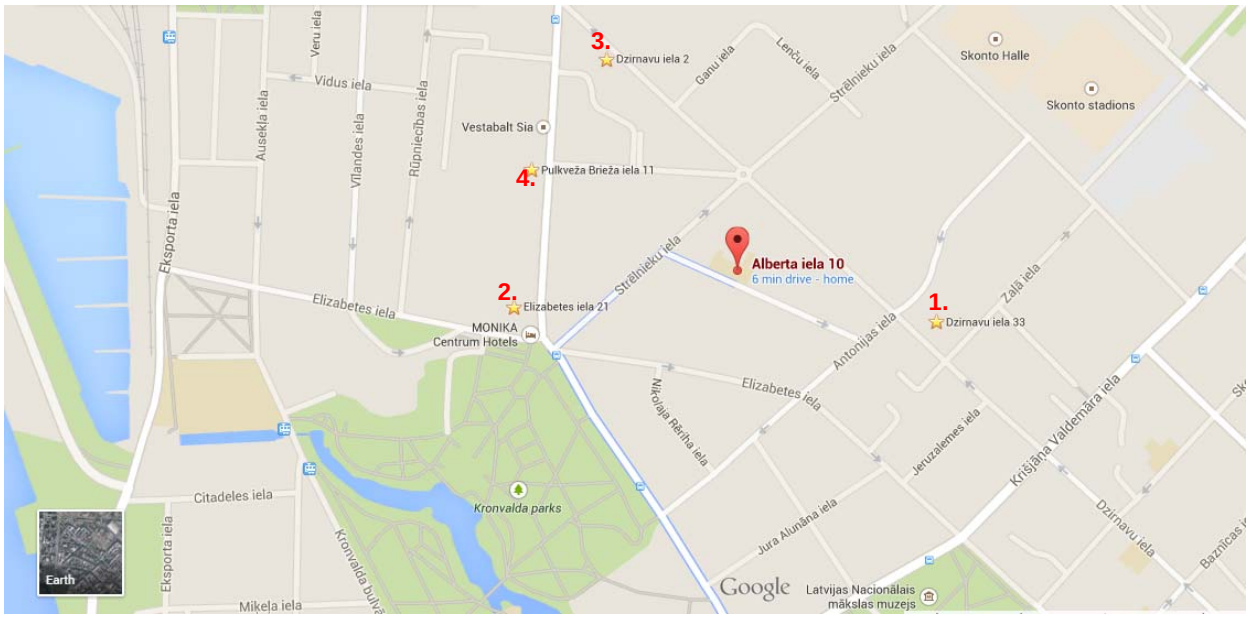

1. Albert Hotel;
2. Monika Centrum Hotel;
3. Wellton Terrace Design Hotel;
4. PK Riga Hotel.

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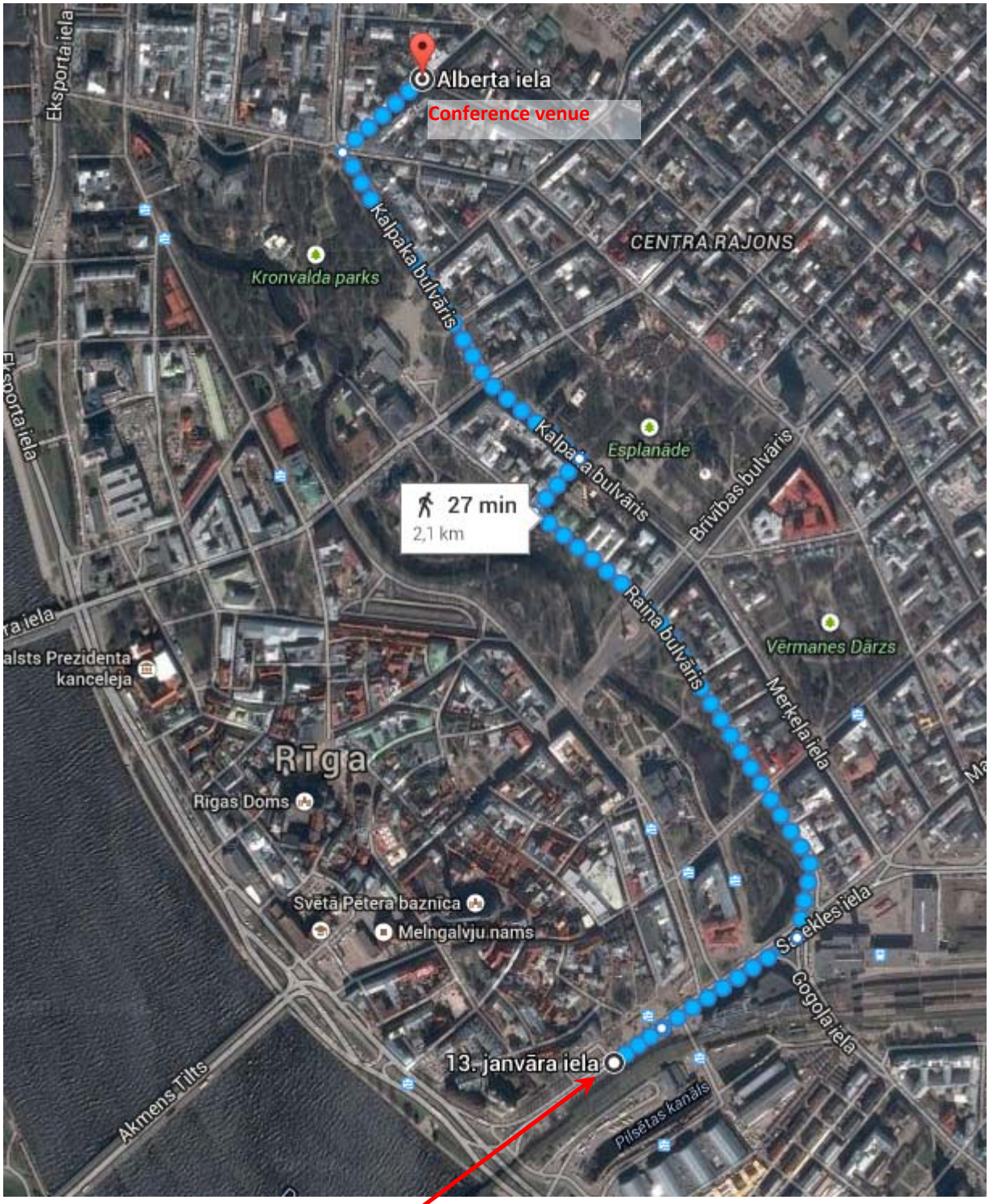

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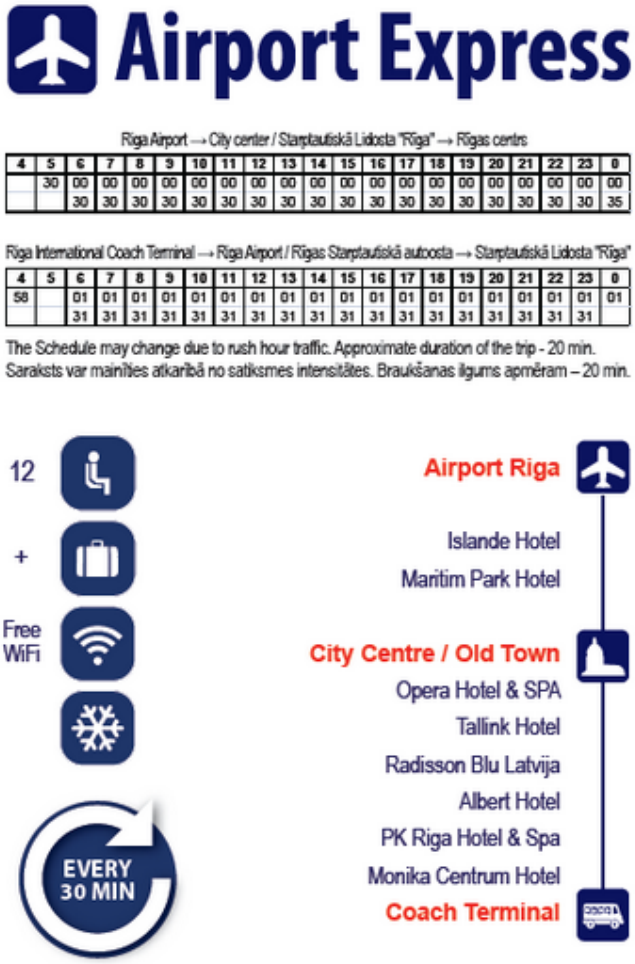
- from the driver (cash only, EUR), at the airBaltic airport ticket office in Riga or at the hotels included in the route.

For more information: +371 26320989



3) Taxi

Riga city and other destinations from the airport can be reached using SIA "Baltic Taxi" and AS "Rīgas Taksometru parks" (*Red Cab*) cabs. Journey time to the centre of Riga city is approximately 15 minutes. Average cost per trip by taxi to Riga city centre: 12-15 EUR. Taxi tariffs are published on the passenger side door of each taxi cab. You can find more information here:

SIA "Baltic Taxi" - link to homepage

AS "Rīgas Taksometru parks" (*Red Cab*) - link to homepage

General Tourist Info: http://www.liveriga.com/en/