Monitoring Ambient Air 2016

Air Quality Monitoring
Evolving Issues and New Technologies

Conference with
Posters and Exhibition

Organised by the
Automation and Analytical Management Group -
Royal Society of Chemistry

Monday 12th & Tuesday 13th December 2016

at the Society of Chemical Industry
14/15 Belgrave Square
London SW1X 8PS

Email: conference@aamg-rsc.org
Website: http://www.aamg-rsc.org

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Monday 12th and Tuesday 13th December 2016
The Society of Chemical Industry, 14/15 Belgrave Square, London

Day 1 - Monday 12th December

09:30 Registration

10:25 Welcome and Introductory Remarks

Session 1: Innovative Measurement Technologies

Chair: **Paul Quincey** - National Physical Laboratory, UK

10:30 Presentation of the findings of the innovative technologies for air quality monitoring report
Stephen Stratton, *Ricardo Energy & Environment, UK*
Margaret Bell, *University of Newcastle, UK*

11:30 Laser based remote sensing of vehicle exhaust
John Stewart Hager, *H E A T, USA*

12:00 Developments in technologies and accuracy for NOx measurements
David Worton, *National Physical Laboratory, UK*

12:30 Short presentations by exhibitors

13:00 **Lunch - exhibition & posters**

Session 2: Particulate Measurements: Ultrafine and Composition

Chair: **Gary Fuller** - King's College London, UK

14:00 Long-term measurements of ultrafine particles in the Ruhr area (Germany)
Ulrich Quass, *I U T A, Germany*

14:30 UFP monitoring at Heathrow airport
Brian Stacey, *Ricardo Energy & Environment, UK*

15:00 Taking ambient air monitoring to the next level - Multiple applications with the Fidas® technology for fine and ultrafine particles measurements
Frederik Weis, *Palas GmbH, Germany*

15:30 Tea / Coffee - Exhibition & Posters

16:00 Characterization of PM pollution within the French CARA program
Olivier Favez, *I N E R I S, France*

16:30 Chemical composition measurements and source apportionment of PM_{10} in Port Talbot
David C Green, *King's College London, UK*

Day 2 - Tuesday 13th December

09:30 Coffee and Exhibition

Session 3: AQEG - Small Sensors

Chair: **Paul Monks** - University of Leicester, UK

10:00 Using a commercial low cost sensor network (Aqmesh) to quantify urban air quality: Comparing measured and modelled (ADMS urban) pollutant concentrations
Rod Jones, *University of Cambridge, UK*

10:30 The CurieuzeNeuzen citizen science project: large-scale air quality mapping of NO_2 concentrations in Antwerp, Belgium
Joris van den Bossche, *Vrije Universiteit Brussel, Belgium*

11:00 Application of low cost sensors in air pollution monitoring
Alastair Lewis, *University of York, UK*

11:30 Tea / Coffee - Exhibition & Posters

Session 4: AQEG - Agricultural Emissions

Chair: **Paul Monks** - University of Leicester, UK

12:00 Agricultural emissions, their contribution to air quality and the likely value of control measures
David Fowler, *C E H, UK*

12:30 The UK particulate episode of March-April 2014: More than saharan dust
Christine Braben, *C E H, UK*

13:00 Low cost sensor for continuous monitoring of the ammonia emission from a pig house
Jacob Mønster, *F O R C E Technology, Denmark*

13:30 Lunch - Exhibition & Posters

Session 5: Exposure Reduction - Photocatalytic Paints

Chair: **T B C** -

14:30 Photocatalytic solutions to mitigate local pollution problems
Robert McIntyre, *Cristal Global, UK*

14:50 Development of more durable photocatalytic coating for pre-coated metal
Chandrakant Mistry, *Becker Industrial Coatings, UK*

Session 6: New Techniques and Recent Developments

Chair: **Karl Ropkins** - University of Leeds, UK

15:10 Controlling air pollution at construction sites
Gary Fuller, *King's College London, UK*

15:30 New method for the measurement of engineered TiO_2 nanoparticles
Stephan Leinert, *L A N U V, Germany*

15:50 On-filter determination of particulate matter oxidative potential: A seasonal analysis of the London particulate airshed
Nuria Camiña, *King's College London, UK*

16:10 Combination of plant monitoring results and weather data as a method to identify PCB-sources
Dieter Gladtke, *L A N U V, Germany*

16:30 Closing Remarks

16:35 Tea / Coffee - Close of Conference

ABSTRACTS

Investigating the Feasibility of Innovative Technologies to Improve Air Quality Monitoring over the Medium to Long Term.

Justin Lingard (lead author)***,*** Tim Scarbrough, Ben Grebot, Federico Karagulian, David Sykes, Alison Loader, Brian Stacey, Paul Willis, ***Stephen Stratton*** (Ricardo Energy & Environment)***, Professor Margaret Bell*** (Newcastle University)***,*** Professor Rod Jones (University of Cambridge)***,*** Professor Paul Monks (University of Leicester)

ABSTRACT

This study sought to identify innovative air quality monitoring techniques and assess their potential ability to meet Defra's medium to long-term (10-15 years) evidence requirements for the UK's national ambient air quality monitoring. The study also aimed to identify and assess potential risks to innovation and market barriers facing such technologies.

Four groups of innovative technologies were identified: **remote sensors** located on satellites; **remote sensors** that are either deployed aloft on aircraft or are ground based; **pervasive sensors** which provide fixed point measurements, and which are characterised as being small, physically robust and deployable in locations that conventional instruments cannot due to constraints in size, weight, access to power and telemetry links; and **fixed-point** automatic analysers similar to those currently used within the UK's national air quality monitoring networks.

A series of high-level risks and market barriers common to most or all of the technologies were identified. The most prominent is the extent (in time and cost) of the process to demonstrate that a measurement technique is equivalent to a reference technique. Other barriers identified include a lack of standardised approaches for processing and validating data from some technologies, lack of or limited development funding, and the risk of lack of technology uptake.

Laser Based Remote Sensing of Vehicle Exhaust

J. Stewart Hager, PhD
Hager Environmental & Atmospheric Technologies (HEAT),
Knoxville, Tennessee, USA

ABSTRACT

Laser based remote sensing has many advantages over other remote sensing methods. Typically, laser base measurements of gases in general is considered to be the most accurate, precise and consistent way of measuring gases. Using DiAL Differential Absorption LiDAR allows for calibration free measurements and consistency from instrument to instrument. The remote sensing of vehicle exhaust gases has been difficult mainly due to unknown properties of the sample. Temperature of the exhaust plume is one of the most important property to know when it comes to accuracy and precision. This makes the remote sensing of vehicle exhaust especially problematic. Vehicle exhaust varies hundreds of degrees centigrade from ambient and from vehicle to vehicle. Laser based remote sensing has the advantage over other remote sensing techniques by choosing individual ro-vibrational absorption features that are insensitive to large changes in temperature. This and other aspects and results of laser based remote sensing will be discussed.

Results from data taken in Connecticut and Arizona in the United States and in Birmingham and London in England will also be discussed.

Developments in Technologies and Accuracy for NO_x Measurements

David Worton and Paul Brewer
National Physical Laboratory, Hampton Road, Teddington, TW11 0LW

ABSTRACT

Accurate measurements of nitrogen monoxide (NO) and nitrogen dioxide (NO_2) are essential as they are key components regulated by European Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe. These components play a key role in ozone formation and influence the oxidative capacity of the atmosphere with implications for air quality and climate change. The most common analytical method employed for measuring NO and NO_2 at monitoring sites is chemiluminescence, as described in the standard reference method (EN 14211:2012), which relies on calibration with traceable NO reference standards. With this method, NO_2 is calculated as the difference between nitrogen monoxide (NO) and total nitrogen oxides (NO_x) after conversion of NO_2 to NO. As such, NO_2 is the only regulated air pollutant that is not directly measured, resulting in more uncertain and less accurate measurements. This presentation will describe the current state of the art for NO_x measurements and required progress to improve their quality and accuracy especially for NO_2.

Long-Term Measurements of Ultrafine Particles in the Ruhr Area (Germany)

***U. Quass*[1],** H. Kaminski[1], M. Küpper[1], T. Kuhlbusch[1,4], B. Hoffmann[2], F. Hennig[2] , S. Leinert[3], J. Geiger[3]J. Sun[5], W. Birmili[5], A. Wiedensohler[5] and other contributers to GUAN

[2]Institute of Energy and Environmental Technology e. V. (IUTA), Duisburg
Institute of Occupational, Social and Environmental Medicine, Düsseldorf
[1]State Agency for Nature, Environment, and Consumer Protection (LANUV), Essen
[4] Federal Institute for Occupational Safety and Health (BAuA, Dortmund)
[5]Leibniz Institute for Tropospheric Research (TROPOS), Leipzig

ABSTRACT

As a part of the German Ultrafine Aerosol Network (GUAN), measurements of UFP number and surface concentrations as well as submicron size distribution have been carried out since 2009 at an urban background site in the Ruhr Area. This site also bears a measurement container belonging to the governmental air quality network which additionally provides PM10/PM2.5 and (since 2013) Black Carbon concentrations.

The aims of this project comprise the evaluation of correlations between the different particle characteristics (number, surface, mass), attempts to identify and quantify sources for UFP and investigations in associations with short-term health effects.

Levels and temporal trends will be briefly presented and compared to other sites of the GUAN network. Source apportionment by Positive Matrix Factorization in connection with weekly and diurnal variations, correlations and wind direction analyses gives indications to the main sources including photochemical formation, traffic exhaust and domestic burning. First epidemiologic analyses investigating the association between particle number and surface area concentrations with short-term effects on natural, cardiovascular and respiratory mortality in the population of adjacent cities (approx. 1 million inhabitants) over a time series of 6 years reveal only subtle effects with different lag-times depending on metric and health endpoint.

UFP Monitoring at Heathrow Airport

Brian Stacey

PhD Student, University of Birmingham, Knowledge Leader,
Ricardo Energy and Environment

ABSTRACT

There is increasing concern that aircraft and airports are a significant local contributor to concentrations of ultrafine particles. Studies at a number of European and US airports have shown that PN concentrations around airports and aircraft approaches may be higher than typical background concentrations.

To date, there have been no similar studies undertaken at UK airports.

In September 2015, Heathrow Airport Limited (HAL), University of Birmingham (UoB) and Brian Stacey began a campaign of UFP measurements at two HAL monitoring stations, to robustly assess UFP numbers around the airport. These monitoring stations already measure NOx, PM_{10}, $PM_{2.5}$, Black Carbon (7-wavelengths), CO_2 and meteorology (at one site), allowing a full picture of air quality around the airport to be investigated.

The campaign measures these pollutants at high temporal resolution, down to 1 minute averages where possible, allowing a multitude of analyses to be assessed, including:

- source apportionment,
- identification and characterisation of individual emission plumes,
- upwind and downwind analyses,
- characterisation from different pollution sources,
- comparison with national network measurement datasets

The campaign runs until December 2016, with a plan for an additional campaign to examine the smallest particles and particle number concentrations at even higher resolution in Summer 2017.

This presentation will outline current background information, present the objectives of the campaigns and give a brief introduction to some of the data already collected.

Taking Ambient Air Monitoring to the Next Level
- Multiple applications with the Fidas® technology for fine and ultrafine particles measurements -

Karsten Pletscher, ***Frederik, Weis****, Maximilian Weiß, Leander Mölter

Palas GmbH, 76229 Karlsruhe, Germany

ABSTRACT

Air pollution due to particulate matter and the related negative effects (health problems, economic damages) has become one of the major problems our society is faced with today. In order to be able to investigate and to assess the real exposition of the general public in a comprehensive way, the performance of precise and accurate measurements of particulate matter is an essential part of air pollution control.

The Fidas® sensor applies the well-approved measurement technology of optical light scattering on single particles and is equipped with a polychromatic LED light source with long-term stable output. The scattered light intensity is detected under 90° through a patented aperture technology, thus preventing border-zone error and enabling for coincidence detection. The implemented approach allows for an easy field calibration as well as a permanent online-monitoring of the calibration status.

Due to its modular design, the Fidas® sensor technique has been adapted to specific devices to cover a large range of possible applications, which will be highlighted in this presentation. It includes regulatory monitoring of PM2.5 and PM10 in official networks by the type-approved and EN-/MCERTS-certified Fidas® 200, indoor and workplace measurements with the portable Fidas® FROG or due to the lightweight sensor technology also installations on flight robots or drones for assessment of line and area sources are possible.

Since the Fidas® sensor delivers not only PM-Values, but also total number concentration and particle with a high time resolution, this can be valuable for e.g. source appointment or prognosis models.

For the monitoring of ultrafine and engineered nanoparticles, the Fidas® is combined with an U-SMPS to measure from 8 nm to 40 µm. The overlapping region of the two systems can then be used for extended characterisation. Examples from nanocomposite recycling or biomass burning will be shown.

Characterization of PM Pollution Within the French CARA Program

***O. Favez*[1],** T. Amodeo[1], A. Albinet[1], J.L. Jaffrezo[2], E. Freney[3], V. Gros[4]

[1] INERIS, Verneuil en Halatte, France
[2] LGGE, Saint Martin d'Hères, France
[3] LaMP, Clermont-Ferrand, France
[4] LSCE, Gif-sur-Yvette, France

ABSTRACT

Since 2008, the French reference laboratory for air quality monitoring (LCSQA) is operating the so-called CARA program along with regional networks to improve the knowledge on PM chemical composition and sources. Historically based on filter off-line analyses (at 10-15 stations), this programs now includes on-line measurements of black carbon and its fossil fuel / biomass burning fractions, using the multi-wavelengths AE33 aethalometer (Magee Scientific), as well as of PM_1 major chemical species, using the Aerosol Chemical Speciation Monitor (ACSM, Aerodyne Research Inc., USA) at 6 various urban sites.

We will present here some of the major findings obtained so far with these real-time analyzers, which notably allowed for a better understanding of the origins of recent persistent pollution episodes. Selected results obtained from source apportionment studies will also be discussed, notably highlighting the diversity of organic aerosols sources (traffic, wood burning, primary biogenic emissions, and various types of secondary organic aerosols) as well as the importance of agricultural NH_3 emissions within the formation of ammonium nitrate pollution episodes.

Finally, we will briefly present on-going activities and recent advances of the Aerosol Chemical Monitor Calibration Center (ACMCC), notably responsible for ACSM calibration protocols, quality assurance and intercomparison within the ACTRIS European research infrastructure.

Chemical Composition Measurements and Source Apportionment of PM_{10} in Port Talbot

***David C. Green*, Anna Font, Max Priestman, Anja H. Tremper**

Port al ot e eriences P 1 concentrations greater than those in the local area these are lin ed to the ma or steel com le his study aimed to identify the ma or sources using high time resolution measurement techniques his is the first time that equi ment ca a le of measuring the full range of organic ionic car onaceous and element com onents has een de loyed at this location ultivariate rece tor modelling as used to differentiate sources of similar chemical com osition from the steel com le as ell as other ur an and remote sources ece tor modelling out uts ere configured to yield 1 1 sources he o timum num er as chosen ased on the minimum model residuals and the correlation et een factor time series n 8 factor solution as chosen as the ideal

o assign hysically meaningful results to the factors several analyses and additional sources of information ere used including the correlation ith no n source rofiles and e ternal measurement time series as ell as a source direction consistent ith no n sources he contri ution of marine aerosol as clearly im ortant contri uting 44 to the mean P 1 concentration ho ever y grou ing the time series y P 1 mass concentration the im act of the different sources on ea P 1 concentrations as identified igure 1 It is clear that emissions from the steel com le nota ly the last furnace and co e ovens ere res onsi le for the ea concentrations

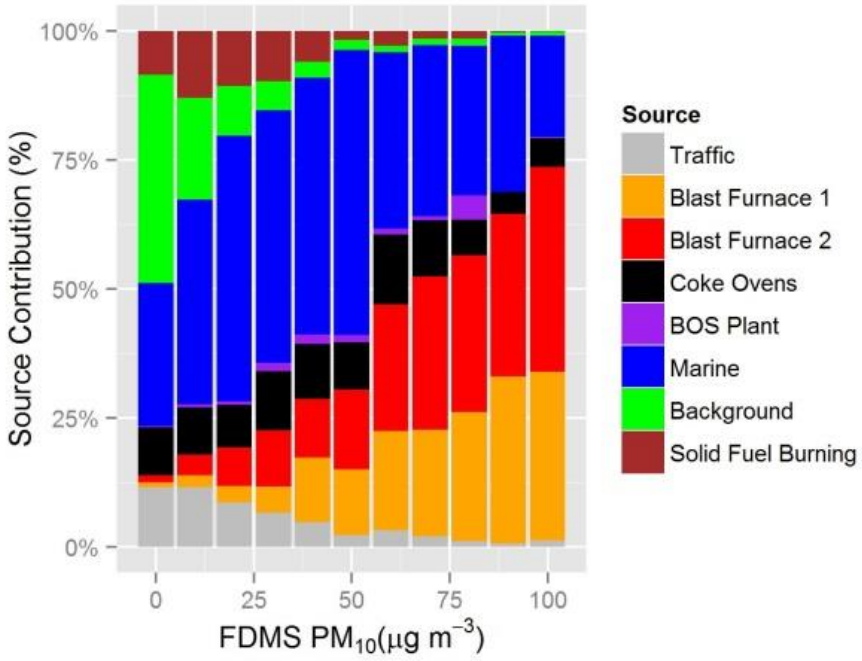

Figure 1: Source categories grouped by PM_{10} mass

Using a Commercial Low Cost Sensor Network (Aqmesh) to Quantify Urban Air Quality: Comparing Measured and Modelled (ADMS-Urban) Pollutant Concentrations

D. Carruthers[1], D. Clarke[2], K. J. Dicks[3], R. A. Freshwater[4], M. Jackson[1], ***R. L. Jones[4],*** C. Lad[1], I. Leslie[5], A. J. Lewis[3], H. Lloyd[4], O. A. M. Popoola[4], A. Randle[6], S. Ulrich[4]

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[2]Cambridgeshire County Council, Cambridge, UK
[3]Cambridge City Council, Cambridge, UK
[4]Department of Chemistry, University of Cambridge, UK
[5]Computer Laboratory, University of Cambridge, UK
[6]Environmental Instruments Ltd., Stratford-upon-Avon, UK

ABSTRACT

We have shown in previous studies the utility of low-cost sensors for monitoring urban air quality. In this study we compare results from a network of commercial low cost sensor nodes deployed across the city of Cambridge with an urban air quality model and results from reference instruments.

The commercial low cost node is the Environmental Instruments AQMesh (http://www.aqmesh.com) which measured CO, NO, NO_2, O_3, SO_2, PM_1, $PM_{2.5}$ and PM_{10} temperature and relative humidity at 1-15 minute intervals. A twenty node network was deployed for a four month period (June-October, 2016), focusing on three main areas, the rapidly developing biomedical campus to the south of the city, a busy city centre thoroughfare, and a new development in North-west Cambridge adjacent to a busy motorway (M11). The model is the CERC ADMS-urban model (http://www.cerc.co.uk) which is widely used for modelling the urban environment. Reference instruments were part of the standard reference networks operated by the Cambridge City Council (https://www.cambridge.gov.uk).

We will begin by presenting an internal intercomparison of the AQMesh nodes. The interlinked components to this study which follow are then a comparison of the reference measurements with co-located AQMesh nodes and the ADMS model. We then extend this to measurements from the AQMesh network and ADMS model outputs. Finally we show how a network of measurements provides additional information particularly for source attribution and use model outputs and measurements to outline how meteorological influences and traffic flow impact Cambridge air quality over the measurement period.

The CurieuzeNeuzen Citizen Science Project: large-scale air quality mapping of NO2 concentrations in Antwerp, Belgium

***Joris Van den Bossche*[1],** Filip Meysman[1]

[1]Analytical, Environmental and Geo-Chemistry (AMGC),
Vrije Universiteit Brussel (VUB)

ABSTRACT

The CurieuzeNeuzen project is a large-scale citizen science project with the objective to map and quantify the spatial variation in air pollution across the city of Antwerp, Belgium. To this end, simple and cost-effective samplers were deployed at nearly 2000 locations. The NO_2 concentration was measured with passive samplers (Palmes diffusion tubes) during 4 weeks in May 2016. At each location, two duplicate samplers were attached to a real-estate panel that was attached to a window pane facing the street. This provided a cost-effective and standardized method of sampling. For data quality control, a similar set-up was deployed at 8 reference monitoring stations located in the study area.

The CurieuzeNeuzen project successfully combined both outreach and scientific data collection. It offered 2000 inhabitants, schools, organizations and companies the chance to measure air quality in their neighbourhood and to be involved in scientific research. At the same time, a high-quality dataset was obtained, which revealed large differences across the city. NO2 concentrations ranged from around 30 µg/m³ within urban greens to over 60 µg/m³ in busy street canyons. Multivariate data analysis identified traffic intensity, street geometry and the distance to the ring road as significant factors explaining spatial variation. A large part of the sampling locations (45±10%) exhibit concentrations that are expected to exceed the WHO yearly limit of 40µg/m³. Overall, the CurieuzeNeuzen project shows how massive, low-cost sampling of air quality with the help of citizens can provide complementary data and insights to traditional monitoring strategies.

Application of Low-Cost Air Sensors in Air Pollution Monitoring

Katie R. Smith [1], Marvin D. Shaw[2], Peter M. Edwards[1,2] and ***Alastair C. Lewis***[2]

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2. National Centre for Atmospheric Science,
University of York, Heslington, York YO194RR

ABSTRACT

Low cost air pollution sensors have substantial potential for atmospheric research and for the applied control of pollution in the urban environment, including more localized warnings to the public. The current generation of single-chemical sensors for NO, NO_2, CO, O_3, SO_2, and VOCs are known to experience varying degrees of interferences from other co-pollutants and impacts from environmental factors such as temperature and humidity. In general sensors are tested in isolation and device-to-device reproducibility of many sensors is not currently well described. This presentation will provide an overview of the development of a range of sensors and highlight how sensor performance characteristics must be carefully considered before matching to particular applications. The presentation will show examples of sensor performance against standard air quality reference instruments, and demonstrate sometimes slow and unpredictable response drifts when multiple (up to 20) identical sensors are co-located and compared. The effects of other co-pollutant chemical interferences on gas sensors will be presented, showing that at lower atmospheric concentrations other chemical interferences can have a significant impact on the measurement. The effects of environmental variables such as temperature and humidity and those associated with autonomy such as battery supply voltage can also impact on results. Strategies for potential improvements in sensor performance will then be presented including statistical approaches that can accommodate the non-linear combinations of interferences found in individual sensors, including Gaussian Process Emulation and Boosted Regression Trees. The use new instruments designed around clusters of identical low cost sensors (specifically for CO and TVOC) will be described, an approach to measurement that can maintain much of the cost / energy competiveness of the sensor concept but where a central value returned from an ensemble of sensor signals is used to overcome the randomized in-service variability of response. Such an approach provides an intermediate step of technological development that offers the potential to increase the range of parameters measured at existing monitoring facilities at low cost.

Agricultural Emissions, their Contribution to Air Quality and the Value of Control Measures

David Fowler

Centre for Ecology and Hydrology

ABSTRACT

Emissions of ammonia from agriculture accounted for 83.3 per cent of total UK ammonia emissions in 2014 and are the main driver for the increase from 2013, increasing from 223 to 234 kt due to larger dairy herds and greater use of Nitrogen in fertiliser. The largest non-agriculture contributions to the total come from waste, road transport and industry (4.7 per cent, 2 per cent and 1.9 per cent respectively in 2014). Unlike emissions of sulphur dioxide, nitrogen oxides and volatile organic compounds, ammonia emissions have declined little over the last two decades. The official inventory suggests a decline of 13% since 1980, but concentrations in air and rain remain largely unchanged over this period.

Emissions of methane from agriculture represent 43% of UK emissions, mainly from the livestock industry and have remained fairly constant at 41MtCO_2 e (7% of GHG emissions) annually over recent years. There is a small removal of methane from the atmosphere by soils over the country by microbial oxidation, but it is insignificant in the national budget.

Agricultural emissions of N_2O dominate UK emissions accounting for ~74% emissions, totalling 22MtCO_2 e annually, and mainly from heavily fertilized pasture. Estimates remain poorly estimated as emission fluxes are highly variable in space and time. Recent improvements in the measurement of N_2O fluxes using eddy covariance methods with quantum cascade laser N_2O instruments are providing long term, large area flux measurements and should reduce the uncertainty in annual emissions in time.

Agriculture is also responsible for emissions of nitric oxide from soils, which are not included in UK emission inventories due to the small annual emission. However, as emissions from traffic and industrial sources decline further, they may need to be included in the UK inventory.

Controls on emissions of pollutant gases from agriculture in the UK have lagged behind other sectors yet other European countries, notably The Netherlands and Denmark have reduced emissions of ammonia by between 30% and 50% over the last decade.

The UK Particulate Episode of March-April 2014: More Than Saharan Dust

M. Vieno[1], M.R. Heal[2], M. M. Twigg[1], I.A. MacKenzie[2], ***C.F. Braban[1]***, R.C. Beck[1], A. Móring[1,2], R. Ots[1,2], C.F. Di Marco[1], E. Nemitz[1], M.A. Sutton[1], E. J. Carnell[1], E. Nemitz[1], J. R. Stedman[3], M. L.Williams[4], and S. Reis[1,5]

[1] Natural Environment Research Council Centre for Ecology & Hydrology; [2]University of Edinburgh; [3]Ricardo-AEA; [4]Kings College London; [5]University of Exeter Medical School

ABSTRACT

Human health burdens associated with exposure to particulate matter (PM) are substantial, however the surface PM concentrations and composition vary with sources (primary emission and secondary formation) and temporal patterns. To inform effective mitigation strategies, timely understanding of short-term episodic concentrations is essential.

A period of UK elevated surface PM concentrations in spring 2014 was widely associated with a Saharan dust plume by the UK media. The surface PM during this period was mainly ammonium nitrate (NH_4NO_3), similar to many UK spring PM episodes. The media reporting may have led to over-emphasis on a natural phenomenon and consequently a missed opportunity to inform the public and provide robust evidence for policy-makers of the causes of the pollution event.

The EMEP4UK regional atmospheric chemistry transport model (ACTM) and hourly speciated PM measurements were used to investigate the sources and long-range transport (including vertical) processes contributing to the Spring 2014 event, particularly the chemical components of the surface PM. Early in the episode, Saharan dust was above the UK, but aloft at several kilometres. In the latter part, Saharan dust did occur at surface level but over a relatively small area in southern UK. The major driver for the surface NH_4NO_3 was agricultural ammonia emissions across continental Europe. PM episodes like this are an annual occurrence in the UK. Advanced ACTMs and UK AQ chemically-speciated measurements (at both the UK Supersites and other AQ networks) can be used operationally to understand air pollution episodes and identify knowledge gaps.

Low Cost Sensor for Continuous Monitoring of the Ammonia Emission from a Pig House

Jacob Mønster*[1]*, Karsten Fuglsang[1], Mathias Andersen[2]

[1] FORCE Technology, Denmark
[2] Danish Technological Institute, Denmark

ABSTRACT

Low cost ammonia sensors have traditionally been developed for detecting leaks in e.g. industrial cooling systems and are therefore not aimed for continuous monitoring in low ppm levels. The current paper presents a test of five different electrochemical ammonia sensors for the use in continuous monitoring. The sensors were tested for detection limit, response time, linearity and precision. The sensors were compared for selecting the best available, low cost ammonia sensor for monitoring the emission from livestock houses in real-time. The selected sensor was subsequently used for real-time monitoring of the ammonia concentrations emitted from a pig house. The ammonia concentrations and the emissions were monitored from different sections of the stable containing finishing pigs at different ages. The measurements were done during several months, and a photoacoustic ammonia analyzer were used to measure the ammonia concentration in parallel with low cost electrochemical sensors.

A newly developed electrochemical sensors from Draeger GmbH showed very good agreement with the reference instrument. Many electrochemical ammonia sensors have a relatively short lifetime due to the consumption of electrolyte inside the sensor during the ammonia monitoring. However, the Draeger EC sensor was developed with an extra electrode, enabling regeneration of the electrolyte and significantly expanding the lifetime and minimizing drift. This allows cost-effective monitoring of the ammonia emission from pig production.

Photocatalytic Solutions to Mitigate Local Pollution Problems

Dr. Robert McIntyre

Cristal Global

ABSTRACT

The quality of the air in our living environment influences the quality of our life. Pollutants from motor vehicle exhausts, harmful releases from chemicals used in our daily life or coming from industrial processes, are all potential sources of diseases and health problems. Photocatalytically treated surfaces can significantly reduce the concentration of those pollutants to safe levels, by converting them in harmless compounds when deployed correctly.

A substantial improvement in the technology for the reduction of pollutants has been made over the past few years... Several environmental agencies and NGOs are raising the awareness of the health risks related to pollution) However NOx levels in the atmosphere continue to be a persistent contributor to the pollution problem and the levels are increasing in many major cities.

Various studies have shown that actions implemented to control pollution such as Low Emission Zones the use of eco-friendly engines and cleaner fuels have not provided the expected results and other technologies are required. Exposure to NOx causes multiple respiratory complications for the global population including airway inflammation in healthy people and increased respiratory symptoms in people with asthma. A recent study revealed that more than 1100 schools, in London, are within 150m distance from roads, carrying more than 10,000 vehicles a day.

We shall discuss previous work on combating pollution using photocatalytic titanium dioxide products as well as plans for a new large scale trial at a school in central London in conjunction with Government experts to prove the efficacy of the technology.

Development of More Durable Photocatalytic Coating for Pre-coated Metal

Dr Chris Lowe, ***Chandrakant Mistry***

Becker Industrial Coatings Limited

ABSTRACT

A photocatalytic coating having both NO_x abatement properties and good resistance to degradation has been developed for pre-coated metal. The coating is a means to reducing exposure to air pollution and can contribute to environmental issues.

Coatings that are intended for use on the exterior surfaces of the building envelope are carefully formulated from raw materials that are known to deliver good outdoor durability. Durability is the retention and maintenance of aesthetic appearance.

An active photocatalytic coating film containing titanium dioxide that is sufficiently effective against NO_x and provides a durable coating with a long period before recoating is required. The period interval between recoating is unknown due to impact to air pollution.

The durability of the photocatalytic coating is under assessment in different environment climatic conditions and air pollution environments.

The active coating surface has beneficial properties of good self cleaning and the removal of particulate matter.

Organic binders have been developed that are somewhat resistant to the degradation chemistry associated with photoactive titanium. After an initial degradation of the organic binder reveals the naked titanium dioxide particle the film remains intact for a considerable period to provide NOx abatement properties.

The performance of the organic binder and level of photocatalytic pigment provides the balance between durable coating and NOx abatement properties.

Controlling Air Pollution at Construction Sites

Gary.W Fuller, David Green and Anna Font

MRC-PHE Centre for Environment and Health,
King's College London,
London, SE1 9NH UK

ABSTRACT

As policies to control air pollution emissions from industry and transport grow ever stronger the spotlight falls on emissions sectors that have not previously been the focus of controls including, most recently, the construction sector. As a consequence London introduced the world's first Low Emission Zone for construction machinery in September 2014 (https://nrmm.london/). Also, dust management programmes are now required for large construction sites including perimeter PM10 measurements and an action limit of 250 µg m-3 (15 minute mean) set to protect the public. This was based on datasets collected in 1999 (Fuller and Green, 2004). This new investigation sought to re-evaluate the 250 µg m-3 threshold as an indicator for construction emissions given newer measurement techniques and changes to urban background PM over the last 16 years.

Pollution measurements from nine construction sites were analysed. Construction projects varied between three months and five years duration and ranged in scale.

Construction PM10 was most apparent in the top 0.3% of measurements. Substantial differences in PM10 concentrations between similar types of construction showed the scope for good site management. Deficiencies were found in the performance of two of the most common instrument types used in perimeter measurements at construction sites. A concentration threshold of 190 µg m-3 (hourly mean) was shown as a reliable indicator of local construction PM10. This would have very low (<1%) false alarm rate if used as part of new dust control programmes.

Reference: Fuller and Green, 2004. Atmospheric Environment. 38, 30, p. 4993 – 5002.

New Method for the Measurement of Engineered TiO_2 Nanoparticles

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ABSTRACT

Little is known about the contribution of engineered nanoparticles to the general load of nano/ultrafine particles in the environment. Usually there is a large background level of unintentionally or naturally produced ultrafine particles (UFP), and industrially engineered nanomaterials are not easily distinguished from the background.

Therefore, measurements were carried out in the vicinity of a plant producing TiO_2-pigments to check if nano-sized product particles are emitted.

Measurements were carried out when there was no rain, and for different wind directions, resulting in measurements both upwind and downwind of the plant.

Measurements included particle size distribution using a Scanning Mobility Particle Sizer (SMPS) as well as collection of individual particles deposited on flat silicon substrates with a Nanometer Aerosol Sampler (NAS) and subsequent analyses by Scanning Electron Microscopy (SEM) and Energy-Dispersive X-Ray (EDX).

Primary particles containing titanium could be identified and were typically 100 to 200 nm in size, and often part of larger agglomerates. They were only found in samples taken when the measurement site was downwind of the plant.

The analysis of individual particles by SEM-EDX allows the quantitative analysis of the contribution of engineered nanoparticles in different size classes.

This methodological approach has been shown to work, and to the knowledge of the authors, has not been published before in the context of engineered nanoparticles in ambient air.

On-Filter Determination of Particulate Matter Oxidative Potential: A Seasonal Analysis of the London Particulate Airshed

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ABSTRACT

The oxidative potential (OP) of ambient particulate matter (PM) has been shown to modify the underlying relationships between $PM_{2.5}$ and cardiopulmonary health. Exploitation of this metric is hampered however by the need to extract PM from filters, with significant inaccuracies when mass loading is low. Such data is needed however to allow successful integration of OP into time series and personal exposure studies, especially when trying to isolate the contribution of urban sources from the regional background. We therefore developed an on-filter method, removing the necessity to extract, based on the direct incubation of 8 mm punches taken from individual filters within a synthetic human respiratory tract lining fluid, containing the antioxidants: ascorbate (AA) and glutathione (GSH). Following a 4 hour incubation OP is calculated, based on antioxidant depletion, to produce an AA and GSH dependent metric, (OP^{AA} and OP^{GSH}), that can be related to the PM mass associated with the filter punch. This method was tested on PM_{10} and $PM_{2.5}$ daily filters collected at four 4 sites (two rural, one urban background and a roadside location) during winter and summer sampling campaigns. Using this method we were able to produce comprehensive daily time series of OP from all four sites, demonstrating clear urban increments in PM_{10} OP^{AA} and OP^{GSH}, as well as increased OP associated with urban PM_{10} and $PM_{2.5}$ during the winter periods. These data demonstrate the feasibility of using this on-filter method to construct time series of OP measurements that can be exploited in low PM environments.

Combination of Plant Monitoring Results and Weather Data as a Method to identify PCB-Sources

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ABSTRACT

In an area in the north of Essen, Germany, curly kale is highly polluted by PCBs.

The spatial distribution of the PCB contamination and the unusual PCB homologue pattern in the samples pointed to a factory recycling electronic waste as a possible source of PCB.

In order to identify the PCB-sources precisely we used a new method to combine data of plant monitoring with wind direction data:

We sampled one year old spruce needles at six points close to the factory. The PCB uptake rate in spruce needles depends on the concentrations of PCBs in air. It is higher the more often the wind blows from the direction of PCB-sources. Thus, concentrations of PCBs in the needles can be looked upon as the sum of the enrichment factors caused by sources, multiplied by the times with wind blowing from their direction. A multivariate linear regression with the PCB concentrations in the needles as dependent values and the times, the wind blew from the sources to the sites, as explanatory variables provides PCB enrichment factors caused by the sources as regression constants.

The highest enrichment factor found was due to the shredder of the plant, the enrichment factors of places with open storage of contaminated material were about four times lower. The PCB enrichment factor from other directions, reflecting the background contamination, was again ten times lower.

POSTER ABSTRACTS

Calibrating Gas Sensors and Verifying Their Application as a Low Cost Substitute to Conventional Air Quality Monitoring

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POSTER ABSTRACT

It is difficult to draw accurate conclusions about air quality because the existing monitoring networks are spatially sparse. Sensors networks, composed of small, low-cost metal oxide (MO) sensors are a potential solution because they exhibit a fast response to changing concentrations of atmospheric compounds and multiple sensor units can be deployed simultaneously to enhance current monitoring datasets. We present data to better understand the selectivity and sensitivity of sensors in both the field and laboratory and have attempted to overcome difficulties such as long term degradation and cross-interference with other prevalent atmospheric gases.

AVEC Plots: a new way to visualise EC/OC thermograms

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POSTER ABSTRACT

Introduction

EC/OC thermal-optical analysis measures the amount of carbon contained in air particulate samples collected on filters. One drawback of this method is the formation of an undesired by-product, the pyrolysed organic carbon (POC). Each sample is normally viewed using thermograms that focus on the instantaneous results from the analyser's detectors over time. As an alternative to these thermograms, we propose focusing on changes in the bulk properties of the sample; plotting laser attenuation vs. evolved carbon (AVEC).

Method

A Sunset Laboratory Thermal-Optical Carbon Aerosol Analyser was used for the EC/OC analysis. Samples from the London area were analysed with two protocols, EUSAAR2 (Cavalli et al, 2010) and NIOSH-like Quartz (Birch and Cary, 1996). The AVEC plot of the analytical data is created from the attenuation of the material on the filter ($\ln (I_0/I)$, where I_0 is the laser transmittance measured at the end of the analysis when all the carbonaceous compounds were desorbed, versus the total carbon evolved (the integrated FID signal), as the analysis proceeds.

Results and conclusions

AVEC plots offer several advantages over the thermograms produced by the Sunset instrument.

- The total carbon and the carbon evolved during each temperature step can be easily read from the x-axis.
- A clear display of any early evolution of EC/POC.
- Information on the formation of POC and evolution of OC.
- Determination of mass absorption coefficients of the combined POC and native EC during the oxygenated phase (Subramanian et al., 2006).
- A clearer split point between OC and EC.

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Field Intercomparison of Ammonia Passive Samplers at Whim Bog

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POSTER ABSTRACT

Ammonia pollution contributes significantly to eutrophication and acidification of ecosystems with resultant losses of biodiversity and ecosystem changes. Monitoring of ambient ammonia over a wide spatial and long temporal scales is primarily done with low-cost diffusive samplers.

This paper will present a field intercomparison conducted within the MetNH3 project to assess the performance of passive samplers for ambient measurements of ammonia. Eight different designs of commercial passive samplers housed in shelters provided by the manufacturer/laboratory were exposed over an 8-week period at the Whim experimental field site in Scotland between August and October 2016. Whim Bog has a facility in place for controlled releases of ammonia (http://www.whimbog.ceh.ac.uk/). Automated conditional release from the line source occurs when the wind direction in the preceding minute is from the southwest and wind speed is > 5 m s^{-1}.

The passive samplers were exposed at different distances from the release source (16, 32 and 60 m) and also at a background location. Most were exposed for 2 x 4-week long periods and some for 4 x 2-week long periods. At the 32 m position, an active denuder method, the CEH DELTA sampler and a continuous high temporal resolution wet chemistry ammonia instrument (AiRRmonia, Mechatronics, NL.) were also deployed alongside the passive samplers to provide reference measurements of ammonia. A summary of the first results and interpretation will be presented within the context of the CATFAC controlled laboratory exposure assessments carried out by NPL, Teddington.

Bonfire Night 2014: Trace gas emissions in Manchester, UK during Bonfire Night 2014

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POSTER ABSTRACT

Biomass burning is a major source of gaseous emissions to the atmosphere that is known to reduce air quality. One example of a regular, nationwide biomass burning event in the UK is Bonfire Night which celebrated annually on the 5th of November by lighting open fires and fireworks as part of community events and at individual households. Concentrations of deleterious trace gases are known to increase due to emission from bonfire night. Polynuclear aromatic hydrocarbons (PAHs) and polybrominated diphenyl ethers (PBDEs) can increase by factors of 4 and 25 respectively (Farrar et al. 2004) and dibenzo-p-dioxins and dibenzofurans (PCDD/F) can increase by factors greater than 10 due to burning household waste on bonfires (Lee et al. 1999). Whilst not representative of typical U.K. biomass burning emissions, bonfire night is demonstrative of how quickly air quality can deteriorate and provides a useful extreme to which other biomass burning events can be compared. A measurement campaign at the University of Manchester was carried out from the 27th of October 2014 to the 14th of November 2014 to assess the impact of bonfire night on local air quality and to contrast the abilities of a quadrupole chemical ionisation mass spectrometer (quad-CIMS) and a time of flight chemical ionisation mass spectrometer (TOF-CIMS) to measure an urban biomass burning event.

Low wind speeds (mean 1.89 ms^{-1}), cold temperatures (mean 5.4^{o}C) and a mean pressure of 998 hPa during bonfire night were indicative of a stable, shallow boundary layer and slow mixing which are conducive to pollution build up. Concentrations of highly toxic nitriles such as hydrogen cyanide, isocyanic acid and methyl isocyanate increased by a factor of 10, 20 and 13 to maximum 1 minute concentrations of 2.86, 5.25 and 0.82 ppb respectively. Other highly toxic species enhanced by bonfire activity include nitrates (nitroformic acid, nitrophenol, methyl nitrophenol, 2-proyn-1-yl nitrate), amides (formamide, formly formamide, methyl formamide and dimethyl formamide) and wood burning products (levoglucosan, hemicellulose, methyl glucose) with maximum concentrations on the order of 10-100s of ppt.

One hour mean NO_2 concentrations peaked at 43.8 µg m^{-3} at 19:00, well below the UK National Air Quality Objective (NAQO) of 200 µg m^{-3}. Measurements of NO_2 between 01/06/2014 and 28/02/2016 at this site indicate the maximum NO_2 concentration of 122.93 µg m^{-3} was measured on 03/12/2014 which is approx. 3

times larger than at bonfire night. The maximum 8 hour running mean concentration of CO during bonfire night was 1,877.8 ug m^{-3} which, whilst below the NAQO, is the largest CO concentration measured between 01/06/2014 and 28/02/2016 at this site. No measurements on the quad-CIMS suffered from interferences caused by the bonfire night event itself. However interferences on the quad-CIMS between $I.H_2O_2^-$ and $I.Cl^-$, and $I.HOCl^-$ and an unknown signal are not found on the TOF-CIMS due to its increase mass resolution. The linearity of HCN and HNCO signal between the two instruments (R^2 = 0.89, R^2 = 0.94 respectively) indicates both instruments are capable of effectively measuring these nitrile compounds.

Farrar, N.J. et al., 2004. Atmospheric Emissions of Polybrominated Diphenyl Ethers and Other Persistent Organic Pollutants during a Major Anthropogenic Combustion Event. *Environmental Science and Technology*, 38(6), pp.1681–1685.

Lee, R.G.M. et al., 1999. Seasonal, anthropogenic, air mass, and meteorological influences on the atmospheric concentrations of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs): Evidence for the importance of diffuse combustion sources. *Environmental Science and Technology*, 33(17), pp.2864–2871.

Airborne ENMs and Possible Implications

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ABSTRACT

Engineered Nanomaterials (ENMs) offer a large potential for a variety of new and enhanced products. However, possible implications on the environment and human health have to be further investigated. While especially the physical and chemical properties of pristine ENMs have been studied in the early state of research on risk assessment, the focus now moves to understanding the functional and behaviour patterns of ENMs in exposure relevant environments. The H2020 project NanoFASE will deliver an integrated Exposure Assessment Framework and addresses fate and transport in real environments, where "environmental cell reactors" are investigated experimentally and multimedia fate models dynamically connect these environmental cells.

The presentation will give a brief outline of the project and will then focus on the work package "Effect of ENM form on environmental fate in air". Its overall goal is the investigation and description of ENMs in ambient air: their emission, transformation as well as their direct atmospheric impact, which will be achieved by an extended literature study as well as by dedicated laboratory and field measurements around a production plant and related to automotive transport.

Results of the Review on "Emissions and Possible Environmental Implication of Engineered Nanomaterials (ENM) in the Atmosphere" will be presented. Furthermore, first results of lab experiments studying (photo)-chemical effects of TiO_2, coated TiO_2 and CeO_2 in a reaction chamber will be shown, that will be used as a basis for the modelling of atmospheric chemical reactions and the degradation of coatings under different conditions.

Residential Combustion, Ambient Air Quality and Human Health In India

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POSTER ABSTRACT

Exposure to fine ambient particulate matter under 2.5µm in diameter (PM2.5) is one of the leading risks to human health. Over a quarter of the global deaths from ambient PM2.5 are concentrated in India. Recent global studies have identified residential combustion as the primary cause of mortality from ambient air pollution in India, contributing over half of the burden. The large grid-scales of these global model studies limit the capture of atmospheric interactions and introduce uncertainty when estimating source-contributions.

This study is the first to estimate the health impacts arising from exposure to ambient air pollution from residential combustion in India at the city-scale. Estimates were produced from simulations with a regional model with chemistry, evaluated against ground and satellite measurements. The regional model allowed for higher-resolutions than global models and therefore better representations of emission sources, non-linear atmospheric processing and transport.

This study highlights that residential combustion is the major contributor to the substantial health burden from exposure to ambient PM2.5 across India. To date this knowledge has not been quantified or has been underestimated, and consequently this study improves air pollution related disease burden estimates for India to form the basis of cost-effective mitigation to air pollution.

Advances and Developments in Personal Aerosol Exposure Sampling, Quantification, and Speciation of $PM_{2.5}$

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ABSTRACT

Research has continued to generate mounting evidence of the toxicity and adverse human health effects of $PM_{2.5}$ exposure. Of acute importance is the ability to detect trace metals within collected samples and the ability to sample in areas of keen interest. Efforts are discussed on obtaining higher sample concentrations and collection methods of $PM_{2.5}$ for the detection of trace metals. Three areas of development have been advanced: 1) measurement of personal exposure including achieving higher flow rates through improved pump performance as well as incorporating a low pressure drop media while maintaining equivalent collection efficiencies and agreement with reference methods, 2) sampling and collection methods have been developed and include improvements to the technology as a human wearable device through the miniaturization of the PTFE media filter. Additionally a drone mounted device has been adopted for point sourcing and research, and 3) robotic laboratory automation has been newly developed to accommodate the miniaturization of filters and provide for speciation measurements. Data is presented on measurement performance of PTFE media, personal samplers, laboratory robotics measurements as well as specifications related to current capabilities. Future field studies are discussed.