AirMonTech

Air Pollution Monitoring Technologies for Urban Areas

January 2011, No. 1

AirMonTech Newsletter

AirMonTech is a European research project co-financed by the European Commission in the 7th Framework Programme

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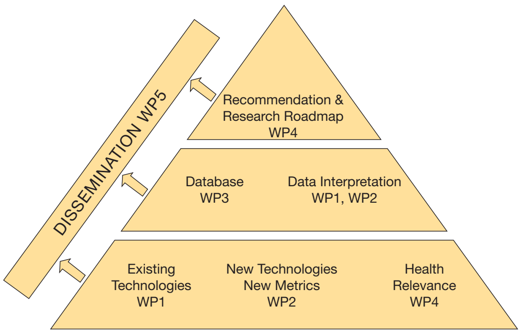
Introduction to AirMonTech

Ambient Air Quality (AQ) is still a major issue of concern in Europe, particularly in urbanised environments where most of the European population lives. Measurements are therefore important for Member States to demonstrate compliance with air quality limits set by the respective EU directives, in some cases to demonstrate the reduction of pollutant levels, and to assess the effect of mitigation measures. The AQ monitoring networks operated by the member states are challenged with continuously increasing quality assurance and quality control (QA/QC) demands on the one hand and on-going innovations and novel monitoring technologies on the other. Moreover, toxicological and epidemiological studies reveal that additional pollutants or characteristics of known pollutants may also be of importance for public health and thus should be included into a comprehensive AQ monitoring strategy.
The EU project AirMonTech, funded by DG Research, was specifically initiated to tackle and to give advice to the above tasks. The project's objectives are



- to provide relevant information on the currently used AQ monitoring technologies, on new measurement techniques and on future AQ parameters to network operators and other stakeholders,
- to identify future needs for improvement of the AQ monitoring networks and give advice on a corresponding research road map,
- and to provide input to the revision of the AQ directive foreseen for the year 2013.

The project is structured into five work packages (see diagram), described in detail below.

First AirMonTech workshop Dec. 14/15 2010

AirMonTech actually started with an internal kick-off meeting and a first international workshop, jointly held with an AAMG-RSC conference at Burlington House in Piccadilly, London. The workshop was attended by more than 120 participants from science, instrument manufacturers and developers, and air quality monitoring networks, as well as national and EU administration. Brief summaries of the presentations are given below; copies of the presentation slides can be downloaded from www.airmontech.eu.

AirMonTech Consortium: (from left) J. Moeltgen (UDE), U. Quass (IUTA), K. Torseth (NILU), K. Katsouyanni (NKUA), B. Vogel (UDE), R. Otjes (ECN), E. Weijers (ECN), P. Woods (NPL), T. Kuhlbusch (IUTA, Coordinator), P. Quincey (NPL), M. Viana (CSIC), R. Gehrig (EMPA), X. Querol(CSIC,) A. Borowiak (JRC), C. Hueglin (EMPA).

The Work Packages in AirMonTech

Existing Technologies for Regulated Metrics

WP1 - Robert Gehrig – EMPA

In order to further improve and harmonise air quality measurements in Europe WP1 aims at compiling information on performance of available instruments for measurement of regulated air pollutants and at providing guidance for the optimal use of the available technologies. To this purpose relevant documents (type approval test reports, standard operating procedures (SOP), equivalence test reports) will be collected and made available in a database.

In an extended discussion the goals and problems of WP1 were addressed during this first AirMonTech workshop, clarifying the expectations of the stakeholders and providing the responsible team of WP1 with suggestions how to further proceed. Making available the type approval tests was generally considered to be useful. Many participants would in addition like the type approval tests to be interpreted, critically reviewed and that important information is extracted. The wish was mentioned that a harmonised structure/scheme shall be established to judge type approval tests. This would facilitate a later mutual acceptance of the tests by other states. However, many manufacturers hesitate to make their type approval reports public and thus give detailed information to competitors. In addition it was made clear that AirMonTech is generally service oriented and provides information. Judgement and/or approval of certain documents are not feasible and also not foreseen in the work programme. This remains clearly the task of the national competent authorities. Also AQUILA members do not necessarily represent the competent authorities responsible for such an approval. Nevertheless, a close collaboration between AQUILA and AirMonTech is considered to be useful and needed.

The collection of SOPs and equivalence test reports from various national and local authorities in a database is considered to be valuable. As an important element of added value the WP1 team should try to extract from the bulk of information a kind of “Standard SOP” containing all crucial points and providing guidance to users in setting up SOPs for their own purposes.
It will be important that all partners including NRLs, networks and manufacturers get on board and collaborate. There is a wish that more techniques than just the reference methods are included. This is already ensured in important tasks of WP2 and WP4 which take into account many aspects concerning additional and new methods and the in-depth discussion of future potentials and needs.

New generation technologies for air pollution monitoring

WP2 - Ulrich Quass – IUTA

The first focus of **Work Package 2** is on new monitoring technologies for already regulated pollutants addressed in WP1 by established technologies. Both commercially-available and research-based technologies will be covered.
The second focus of WP 2 targets as-yet- unregulated air pollutants and health-related proxy compounds (e.g. ultra-fine particles, particle surface area, heavy metals, soot) and innovative monitoring instrumentation (e.g. multi-component analysers, like differential optical absorption spectrometry (DOAS) for gas phase compounds and aerosol mass spectrometry (AMS) for particles.

For all these instruments technical and performance information will be compiled and made accessible via the database provided by WP 3.
The potential of such instrumentation to improve current air pollution monitoring in terms of temporal and spatial resolution, population exposure assessment, evaluation of pollution reduction measures and their use for validation of micro-scale air pollution models will be assessed. These results will consequently form important basic information for developing recommendations for future urban air quality monitoring and related research needs, which is the major task of WP 4.

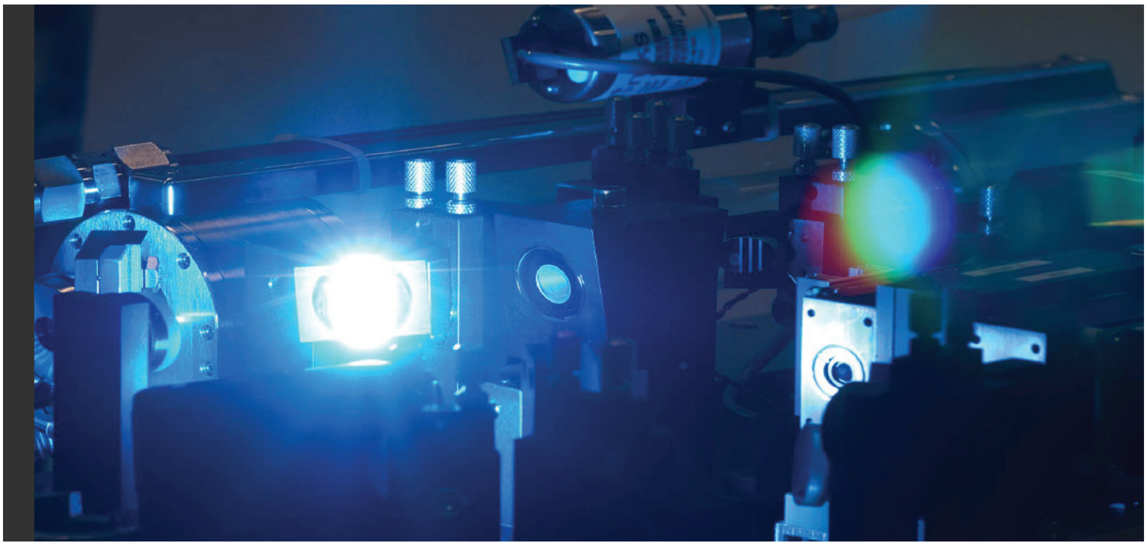


figure 1 New laser based methods may improve future AQ monitoring (photo: EMPA)

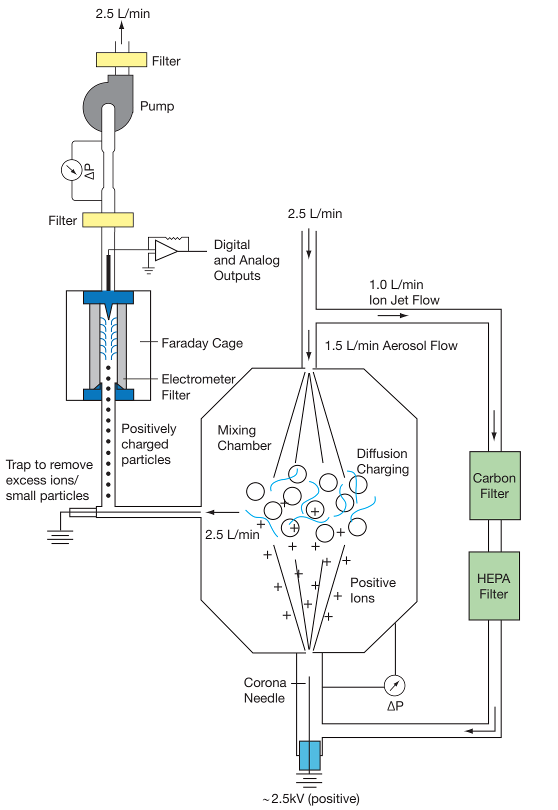


*figure 2 Principle of the nanoparticle surface area monitor (NSAM, courtesy of TSI GmbH)
Fissan et al.(2006), J. Nanop. Res.9: 53-59;
Shin et al.(2006), J. Nanop. Res.9: 61-69*

The Database
WP3 – Annette Borowiak - JRC

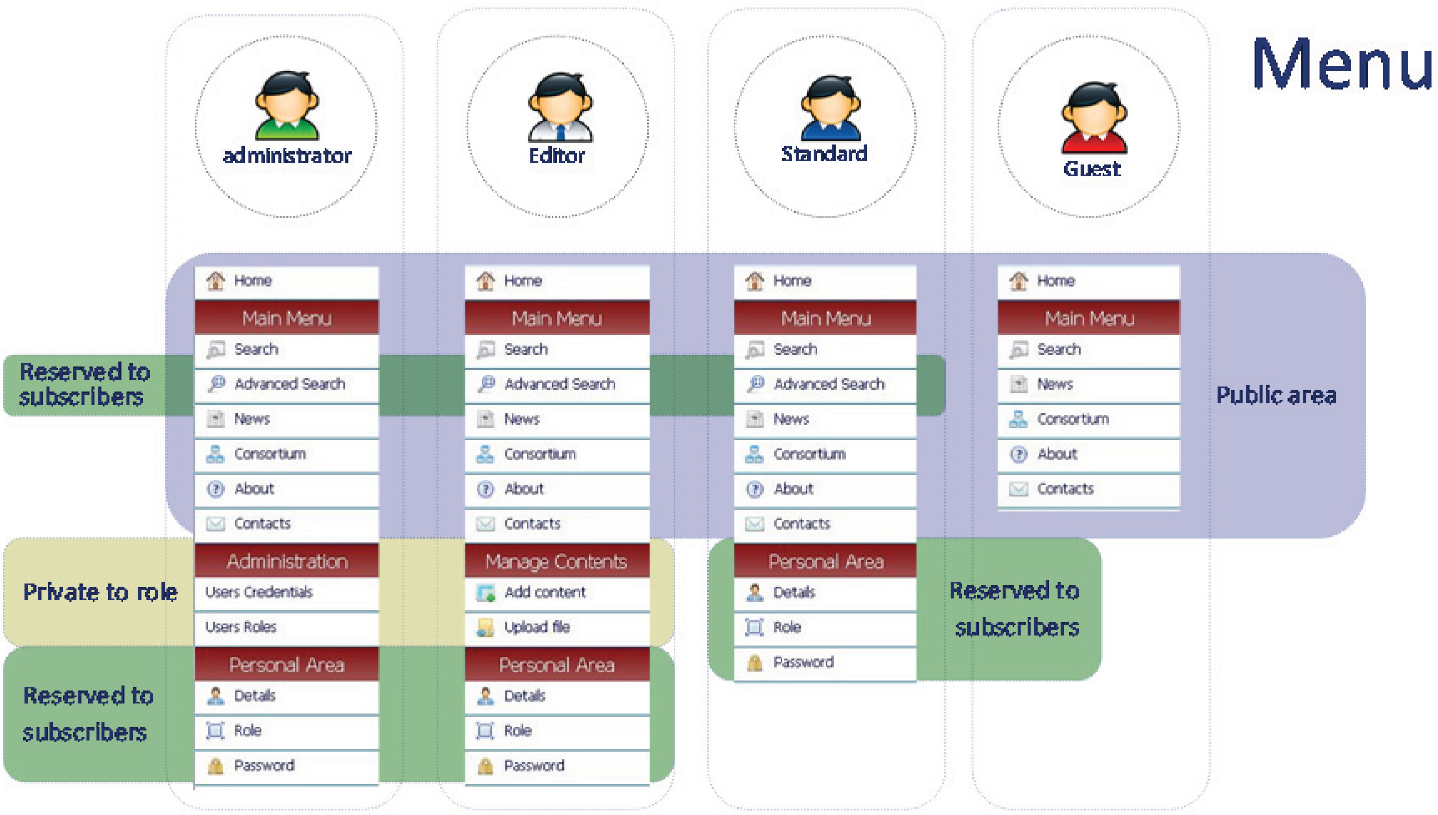
JRC
EUROPEAN COMMISSION

The AirMonTech database will collect information on air pollutants, measurement techniques, instrumentation, type approval, equivalence tests and standard operating procedures. The architecture of the database shall comprise three layers: The top layer is the graphical user interface. Its main function is to translate tasks and results to something the user can understand. The middle tier coordinates the application, processes commands, makes logical decisions and evaluations, and performs calculations. It also moves and processes data between the layers. In the data layer information is stored and retrieved from the database or file system. The information is passed back to the logic tier which eventually sends them back to the presentation tier. Authentication within the database will be done via subscription and email verification. Different roles will be managed within the database: A system administrator (JRC), editor(s) and standard user(s) and guest(s). The role interactions, logical views of the system organization and search options still need to be decided.

During the December AirMonTech workshop in London important feedback was received by the workshop participants on

- dissemination strategy and involvement of US, Asia, Central and Eastern Europe,
- the need for an evaluation of retrieved documents regarding completeness and conformity of instrumentation or tests, and
- establishing links to AirBase and GMES.

The AirMonTech database



Monitoring Strategies and Research Roadmap
WP4 - Paul Quincey - NPL

Work package 4 will make overall recommendations based on the results of other Work packages (especially WP2), and other factors such as health and strategic considerations. Some of the themes that emerged from the discussion were that:

(1) The philosophy for the regulated metrics, solely with regarding to protecting human health from pollutants with known harmful effects, needs to be explicit:

- are they supposed to focus on the most polluted areas (as is the consequence of a blanket "limit value" approach)? or
- are they supposed to focus on maximum relevance to the population (where an "average exposure indicator" may be more appropriate)?

The design of regulatory monitoring networks will be different in the two cases.

(2) Ultimately, what matters is personal exposure, which is a combination of ambient, indoor (domestic), workplace, and in transit (eg in-car or on train) exposure, but to implement this in regulatory terms would go far beyond what is practical in the project timescale.

(3) The role of the regulatory monitoring network is much wider than simply assessing compliance with limit values or average exposure indicators from pollutants with known harmful effects. Ideally the regulatory network would:

- assess compliance with regulated pollutants
- provide data to further evaluate the health effects of the regulated pollutants
- provide data to validate and improve air quality models
- provide the means of evaluating source apportionment for the pollutants
- provide the means of evaluating the effects of specific pollution control measures
- provide data that would evaluate which regulated or non-regulated pollutants were most suitable for regulation in future.

In other words the regulatory networks should have specific research functions as well as regulatory functions. The major investment by Member States in regulatory monitoring should be planned to maximise the benefits, and coordinate with other data, in a premeditated way.

In general, the possible elements in the structure of regulatory monitoring were seen to be:

- fixed site monitoring (high accuracy, limited representatively)
- mobile monitoring (lower accuracy, higher representatively)
- remote monitoring (ie satellite / GMES type)
- modelling

Most discussion concerned the relative emphasis on fixed and mobile monitoring within a regulatory network. It was generally considered that there would be progressively less fixed site monitoring and more mobile/low cost monitoring in the future. Radical changes would not be desirable both for continuity reasons (eg for health studies) and on grounds of cost.

Talks

Presentations: First Day

WP1 was introduced by **Christoph Hüglin**, EMPA who presented the main tasks of this work package, which should support further improvement of the harmonisation of air quality measurements in Europe:

- Compilation of information on performance of available instruments for measurement of air pollutants as regulated in Air Quality Directive 2008/50/EC.
- Provision of guidance for optimal use of the available instruments and measurement technologies.
- Provision of easy access to this information through databases (created within WP3).

To this purpose relevant documents (type approval test reports, standard operating procedures (SOP), equivalence test reports) should be collected and made easily available in a database.

Peter Woods, NPL discussed the requirements for type approval of continuous reference methods including the issues of QA/QC methodologies and uncertainties.

The talk by **Ulrich Pfeffer**, LANUV on equivalence tests for PM measurements, where continuous non-reference methods are often used, showed the requirements for such tests and illustrated the numerous problems in this field with relevant data.

Theo Hafkenscheid, RIVM clearly demonstrated the crucial importance of ongoing QA/QC for PM monitoring and described the status of a draft standard currently developed within CEN.

The European Directive 2008/50/EC requires that EC and OC measurements are performed, but no reference method has yet been defined. Jean-Philippe Putaud, JRC described the challenges involved with these measurements and about the EUSAAR2 protocol aimed at harmonising EC and OC measurements in Europe.

Robert Gehrig, EMPA drew attention to significant differences that occur when specific NO2 measurements are performed with photolytic converters instead of the commonly used molybdenum converters with their known interferences from various other nitrogen compounds.

Nadine Locoge, Ecole des Mines de Douai compared various techniques for measurements of benzene and raised concern about significant differences between different methods.

Annette Borowiak presented the database architecture and a suggested a structure to the Workshop participants. The following questions were given to the community:

- Which database filters would you recommend for advanced search on the website?
- Suggestions for navigation pattern/logical views?
- Shall we restrict the use of the database/what user information shall be provided and stored?
- Shall we build a 'network' within the database where members can rate and comment contents and interact with other members?

Michel Gerboles from JRC ISPRA (I) introduced the potentials of small chemical sensors for ambient air monitoring of gaseous pollutants (NO2, O3, NO, CO, NH3, SO2, benzene). Recent advances in micro-and nanotechnology led to better sensitivities and for NO2 and O3 the data quality objectives for indicative methods as set by the AQ directive could be met in the near future. For SO2, applications are limited to high concentrations, for examples ship exhaust plumes.

The possibility to visualise micro-scale concentration gradients of trace gases with high time resolution by novel portable DOAS systems was enthusiastically presented by **Mark Richards** from Imperial College London (UK). The potential to produce pollutant maps for entire cities as well as to monitor exposure while walking or driving was outlined. Major challenges for an extended use of such systems are seen in the development of dynamic measurement routines and data representation.

Laser-based instruments, like Cascade Laser Absorption Spectroscopy (QCLAS, specifically measuring NO2) and Cavity-Ringdown Spectroscopy (CRDS, for CO, CO2, CH4, H2O) were presented by **Christoph Hüglin** of EMPA (CH). Such instruments offer high sensitivity and temporal resolution, as needed e.g. in special remote background networks (GAW).

Presentations: Second Day

A brief introduction on the scope and expectations of WP2 was given by **Ulrich Quass** of IUTA (D). Both new instruments for already regulated and monitored pollutants, and innovative monitors for non-regulated compounds and proxy parameters are covered by this WP.

The session on new pollutants and proxy compounds was started by a presentation of **Klea Katsouyanni** from Athens University (Gr) on the principal methodologies in environmental epidemiology and the state of knowledge about air pollutant related health effects. With respect to airborne particles some evidence appears that surface concentration may be an important parameter. More insight already exists on UFP number concentration which appears to represent traffic emissions and to be related to cardiovascular effects. She pointed out that from the viewpoint of health science the data needed always depends on the health endpoint to be considered. Therefore, at present no general selection criteria as to which pollutant metrics should be preferentially monitored can be given.

Frank Kelly from King's College London (UK) reported on recent developments of assays for measuring the oxidative properties of airborne particles. These parameters, like antioxidant depletion and reactive oxygen species generation, are presumed to be more directly linked to health relevant effects than specific chemical compounds. Several different and complementary methods already exist, however none of them has so far been developed into automated monitoring systems.

According to the presentation by **Thomas Kuhlbusch** (IUTA Duisburg, D) measurements of the alveolar particle surface area appear to be another promising proxy of integral aerosol characteristics related to health effects. Automated measurement devices are already commercially available and proved to be robust and reliable. Since correlation with UFP number concentration is weak surface measurements provide an independent parameter for epidemiological studies.

Bioaerosols were in the focus of a presentation given by **Dimitris Sarantaridis** of University College London (UK). He showed first experiences with a new detection principle based on the electrochemical features of the plasma being formed when pollen are combusted in an hydrogen/oxygen flame.

A group of automated monitoring instruments applying the principle of wet aerosol sampling was addressed by the talk of **René Otjes** of ECN (NL). Some instruments to simultaneously monitor water soluble gases and aerosol compounds (like NH3/NH4, HNO3/nitrate) as well as other anions and cations are already on the market. A few more exist on the research level. While these systems have significant advantageous with respect to sensitivity and temporal resolution compared to manual filter based methods they still lack of reliable calibration methods.

Xavier Querol from CSIC (Es) reported on the possibility of using source-related contributions to airborne particles, as provided by source apportionment studies, as proxies. Since source apportion methods usually need both a high number of observations and measurement of many chemical constituents, such an approach is unlikely to work in a routine monitoring network. On the other hand, for certain sources to be distinguished, like emissions from traffic and domestic heating, simpler methods based on automated measurements of black carbon and nitrogen oxides are available.

Wolfram Birmili (IFZ, Germany) presented the German Ultrafine Aerosol Network (GUAN), which is a cooperation of research institutes and public service institutions with the aim of improving our picture of the health and climate-relevant properties of atmospheric aerosols. The network employs uniform quality assurance and quality control procedures, data processing and dissemination of the data, often based on EUSAAR protocols, for:

- sub-µm particle number size distributions
- non-volatile (300°C) number size distributions
- soot mass concentrations (MAAP)
- size-segregated chemical composition
- particle hygroscopicity.

The sites are mainly rural (including EMEP, EUSAAR and GAW sites), with 1 semi-urban, 3 urban and 2 roadside sites. Instruments are intercompared every 4 years. Usually differences between instruments lower than 10% for total number, volume, surface. For particle numbers in the range 10 to 20 nm, differences are around 30%. A summary of results was presented.

Paul Quincey (NPL, UK) reported on activities related to ultrafine particles in the UK. The UK government (Defra) initiated the continuous measurement of particle number concentration (with 7 CPCs) and particle size distribution (with 3 SMPSs) in 1998. Sites were initially predominantly urban background to provide data for epidemiology. In 2006 the SMPSs were upgraded with more recent models. Since 2007, the network has been restructured to provide a London trio (roadside -Marylebone Road, N. Kensington – urban background and Harwell – rural) while retaining a CPC in Birmingham. The first 3 sites also monitor EC/OC and anion composition.
Instrument operation and QA/QC has evolved with improved understanding and as recommendations have emerged from EUSAAR, CEN and elsewhere. For example, the inlet systems now incorporate PM1 impactors, and driers to keep the relative humidity below 40%. A CPC calibration service has been developed at NPL, linked to other National Measurement Institutes.

In a study presented by **Evi Dons** (VITO, Belgium) micro-aethalometers were used to monitor the personal exposure to Black Carbon of 16 people in Flanders (8 couples – one home based, one out working), who were also equipped with GPS and electronic diaries to log their activities. All participants had diesel cars and did not smoke.
The highest exposures were during travelling (especially car driving) and shopping, the lowest when sleeping. Transport accounts for only 6% of time, but can be up to 25% of exposure.
The results highlighted the differences between personal exposure and ambient air concentrations, with differences in exposure between couples at the same address of up to 30%.

Martine van Poppel (VITO, Belgium) introduced a novel measurement strategy. A bicycle (called Aeroflex) was used to map pollution in Belgian cities. This has advantages over fixed monitoring sites with regard to human exposure, and this is especially true for highly inhomogeneous pollutants such as ultrafine particles. It is also good for locating hot spots and gauging the representatively of fixed sites. The bike was equipped with a portable particle number counter, an optical PM10 / PM2.5 instrument, a micro-aethalometer for Black Carbon, a sound meter, GPS and a data transmission system. A case study was presented, showing very reliable production of data and ease of data presentation on Google map – 20 datasets lasting 41-59 minutes over 10 days, in a variety of meteorological conditions. Particle numbers and Black Carbon were correlated and showed much greater spatial variation than the PM10 / PM2.5.

Challenges and Perspectives for EU Air Quality Policy were presented by Emile de Saeger. (EU, DG Environment, Brussels. Ambient Air Quality is now covered by DG ENV Unit C3, which includes

Industrial Emissions, Air Quality, Accidents and Noise. Current work includes assessing time extension notifications, implementing the 2008 Ambient Air Quality Directive (eg revising guidance, making use of EIONET, AQUILA and FAIRMODE), and the revision of AQ policies by 2013.
Fit-for-purpose measurements are seen as vital, with key current measurement challenges for AQ being PM10 / PM2.5 (artefacts in the reference method, equivalence testing, average exposure indicators); PAH and Heavy Metals methods; supporting assessments (ozone precursors, EC/OC, anions/cations); and over-estimation of NO2 levels. Future directions for AQ measurements were seen as:

- a move from ambient monitoring to indoor and personal monitoring
- making metrics more health relevant, eg toxic PM components
- making use of new monitors, eg micro-sensors and spectroscopic techniques
- linking data to GIS and earth observation ie GMES/PROMOTE
- making more use of mathematical models, combined with fewer but better measurements.

Kjetil Tørseth (NILU, Norway) of the EMEP Chemical Coordination Centre reported on coordinated measurements of atmospheric composition and deposition fluxes that were initiated in the early 1970s through the OECD project on Long Range Transport of Air Pollutants, which led to the CLRTAP convention and its European Monitoring and Evaluation Programme (EMEP). Standardised operation and QA/QC has been developed, starting with the 1977 Manual for Sampling and Analysis, and with the first intercomparison taking place in 1978. Standard methods have been developed where none were available.
There has been a special focus on background sites (the joint EMEP-WMO/GAW sites). A great deal of historical and current data and guidance are available through websites such as www.emep.int and www.gaw-wdca.org.

Outlook

In the upcoming months the experiences and information gained at the 1st AirMontech workshop will be evaluated in the light of the project objectives. Further information will be gathered on instrument performance, test results, equivalence demonstrations and SOPs, and uploaded into the specifically designed database. Calls for additional information will be send out per email in the coming months. A roadmap for future urban air quality monitoring including recommendations on existing and new monitoring technologies will be developed. Special attention will be given to the dissemination of the project and its results to the eastern European countries. Results will be discussed during the next workshop to be organized in the course of 2012. The final announcement can be found on the website: www.airmontech.eu where you can also subscribe on the regularly published Newsletter with the latest news facts.

Imprint

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