

AIRMON 2008

Sixth International Symposium on
Modern Principles of Air Monitoring
and Biomonitoring

January 28-31, 2008

Dr Holms Hotel, Geilo, Norway

www.airmon.se

Program and Book of Abstracts

Welcome to AIRMON 2008 and Geilo!

There is a long-continued requirement of air monitoring within the preventive framework of identifying and controlling health hazards at the work place and in the environment. For the characterisation of exposure to chemical and biological agents, sensitive, selective and user-friendly methods and relevant sampling strategies are needed. In recent years there has been a continuous development in the area of air monitoring, and it is essential to promote the knowledge of newly developed methods and strategies for workplace, indoor and ambient air monitoring. Five previous meetings have been held: at Geilo, Norway in 1993 and 1999; in Sälen, Sweden in 1996; at Hafjell-Lillehammer, Norway 2002 and in Loen, Norway 2005.

The programme of **AIRMON 2008** has been planned with a view of furnishing a comprehensive overview of the latest developments in this important field. Since some of the world's leading authorities in the field will be present, the symposium will be an excellent forum for the exchange of ideas as well as an opportunity for private informal discussions, for all those who are involved in method development, air sampling, exposure assessment, regulatory issues or other areas related to air monitoring and biological monitoring.

All contributions (including posters) will be considered for publication in a special issue of the Royal Society of Chemistry *Journal of Environmental Monitoring* after the symposium.

On behalf of the organisers it is our pleasure to welcome you to Geilo. We promise you an exciting and memorable stay!

Jan Olof Levin, Yngvar Thomassen,

Dietmar Breuer, Peter Görner, Alan Howe, Olle Nygren

Organisers

AIRMON 2008 is organised by the Umeå University (UmU), Sweden, National Institute of Occupational Health (NIOH), Norway, Health and Safety Laboratory (HSL), UK, the Institute for Occupational Safety and Health (BGIA), Germany, and Institut National de Recherche et de Sécurité (INRS), France.

Organising Committee

Jan Olof Levin, Umeå University, Chairman
Olle Nygren, Umeå University, web
Yngvar Thomassen, NIOH, Oslo, secretariat
Dietmar Breuer, BGIA, Germany
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Institut für Arbeitsschutz der
Deutschen Gesetzlichen Unfallversicherung



Health & Safety Laboratory

An Agency of the Health & Safety Executive



Information for Contributors

The official language is English. No simultaneous translation will be provided. Oral presentations will be 30 or 60 minutes, discussion included. Overhead will be provided in the lecture hall as well as digital projection with PowerPoint software. Lecturers are requested to deliver the PowerPoint files to the technician responsible well before the start of the session. A special presenter's room will be placed at the disposal of the lecturers. Posters will be displayed from Monday to Wednesday in the Conference Centre. Authors are requested to be at their posters Monday and Tuesday between 16:00 and 17:00. At least one of the authors must be present at the poster during this time.

All contributions will be considered for publication in a special issue of the Royal Society of Chemistry (RSC) journal *Journal of Environmental Monitoring* after the conference, subject to the normal review procedures of the journal. Authors are kindly requested to hand in their manuscripts at the Symposium, the final deadline being 1 March 2008.

General information

Venue

All sessions will be held in the various auditoriums of

Dr Holms Hotel
P.O. Box 38, N-3581 Geilo
Timrehaugvn. 2, N-3580 Geilo, Norway
Tlf.: + 47 32 09 57 00
Fax.: + 47 32 09 16 20
E-mail: post@drholms.com

Secretariat

The Symposium Secretariat is situated in the Conference Centre.

Registration

Participants are requested to register at the Secretariat on Sunday, January 27, between 16.00 and 18.00. Participants are requested to wear their name badges throughout the Symposium, as it is the admission card to the scientific programme.

Payment

Unpaid registration will be added to your hotel bill and collected by the hotel upon arrival.

Liability

The Organising Committee declines any responsibility whatsoever for injuries or damages to persons or their property during the Symposium.

Exhibition

The Instrument Exhibition will take place in the Conference Centre. It will be open Monday - Wednesday. The participants are encouraged to visit the exhibition. The following companies have registered for display and demonstration:

Grimm Aerosol Technik GmbH & Co KG
LECO Corporation Svenska AB
Markes International Ltd
Massanalys Spectrometry Nordic AB
Oleico AB
Scantec Miljöinstrument AB
SKC Ltd
Sigma-Aldrich
Yara Praxair AS

Program Sunday, January 27:

16:00: **Registration**

18:00: **Informal get together**

19:30: **Dinner**

Short Courses

Monday, January 28:

1. A Howe, G Carter, G Lidén, and D Mark:

Sampling and Analysis of Welding Aerosols

2. G Skarping

How to select a method for isocyanate monitoring in the workplace

Tuesday, January 29:

3. J H Vincent:

Field experience with aerosol samplers in workplaces

4. A Hyvärinen

How to deal with dampness/moisture problems from a practitioners' point

5. A Whisthaler:

An introduction to Proton-Transfer-Reaction Mass Spectrometry (PTR-MS)

Wednesday, January 30:

6. J H Vincent

Field experience with aerosol samplers in the ambient atmosphere

7. O Nygren

On site measurements - a tool for direct assessment of exposure

Oral Presentations

Monday, January 28:

07:30-08:00: **Registration**

08:00-08:30: **Welcome/Opening remarks**

**Session I: Environmental and occupational exposure assessment –
Strategies and methodologies**

Chairman: Jan Olof Levin

08:30-09:00: **Development of experimental methods for studying inhalability and personal sampler performance for aerosols in ultralow-wind speed environments**

Darrah K. Schmees, Yi-Hsuan Wu, and James H. Vincent,
University of Michigan, USA

09:00-09:30: **Online monitoring of VOC by proton-transfer-reaction mass spectrometry (PTR-MS)**

Armin Wisthaler and Armin Hansel, University of Innsbruck, Austria

09:30-10:00: **Glyoxal-DNA adducts as biomarker candidates for determination of glyoxal exposure**

R. Olsen, P. Molander, S. Øvrebø, National Institute of Occupational Health, Norway, and University of Oslo, Norway, E. Lundanes, T. Greibrokk, University of Oslo, Norway

10:00-10:30: **Coffee, exhibition, poster viewing**

10:30-11:00: **Chemical markers of microbes in exposure assessment**

Anne Hyvärinen, Hanna Vehosmaa, Aino Nevalainen, National Public Health Institute, Finland

11:00-11:30: **Spatial mapping of atmospheric pollutants for European scale population exposure assessments**

Bruce Denby, Norwegian Institute of Air Research, Jan Horálek and Pavel Kurfurst, Czech Hydrometeorological Institute, Frank de Leeuw and Peter de Smet, Netherlands Environmental Assessment Agency and Jaroslav Fiala, European Environmental Agency

11:30-12:00: **Methods for determination of isocyanates and related compounds in air**

Gunnar Skarping, Marianne Dalene, Daniel Karlsson and Jakob Dahlin, Stockholm University, Sweden

12:00-12:30: **Biological monitoring for isocyanates: A guidance value and its application**

Kate Jones and John Cocker, Health and Safety Laboratory, UK

12:30-13:00: **Occupational exposure to organophosphates originating from hydraulic fluids**
Kasper Solbu¹, S. Thorud¹, S. Øvrebø¹, D.G. Ellingsen¹,
E. Lundanes² and P. Molander^{1,2},
¹National Institute of Occupational Health, Norway and ²University of Oslo, Norway

13:00-16:00: **Lunch and outdoor activities**

16:00-17:00: **Poster viewing, exhibition, coffee**

Session II: International regulations, standardisation and quality assurance

Chairman: Peter Görner

17:00-17:30: **International standardisation in the field of workplace air quality**
Alan Howe, Health and Safety Laboratory, UK

17:30-18:00: **Proficiency testing scheme for the industrial hygiene laboratory performance assessment**
Eddy Langlois, Institut National de Recherche et de Sécurité, France

18:00-18:30: **Production of test gases in the ppb range for round-robin tests or quality assurance measures during the measurement of VOCs**
Andreas Moritz and Dietmar Breuer, BGIA – Institute for Occupational Safety and Health of the German Social Accident Insurance, Germany

18:30-20:00: **Short courses**

20:00: **Dinner**

Tuesday, January 29:

Session III: Progress in sampling and characterisation of exposure

Chairman: Yngvar Thomassen

08:00-09:00: **Conceptual and practical approaches to assessing exposure to nanoparticles**
Thomas Schneider, National Research Centre for the Working Environment, Denmark

- 09:00-09:30: **Workplace measurements of ultra fine particles - practical considerations and current experience**
Carsten Möhlmann, BGIA - Institute for Occupational Safety and Health of the German Social Accident Insurance, Germany
- 09:30-10:00: **An international sampling convention for inhalable dust in calm air?**
Göran Lidén, Stockholm University and Martin Harper, National Institute for Occupational Safety and Health, USA
- 10:00-10:30: **Journal of Environmental Monitoring's 10th Anniversary Lecture: 3D dimensional modelling of aerosol samplers for unsteady conditions**
Albert Gilmutdinov, Ilya Zivliskii and Shamil Zaripov, Kazan State University, Russian Federation
- 10:30-11:00: **Coffee, exhibition**
- 11:00-11:30: **Aerosol sampling by annular aspiration slots**
Peter Görner, Olivier Witschger, Richard Wrobel, Jean-François Fabriès, INRS-Institut National de Recherche et de Sécurité, France and Florence Roger, SGN, France
- 11:30-12:00: **Comparisons of fiber concentrations using different thoracic samplers and slide mounting methods**
Eun Gyung (Emily) Lee, Martin Harper, John Nelson, Patrick J. Hintz, Gerald J. Joy, Institute for Occupational Safety and Health (NIOSH), USA
- 12:00-12:30: **Monitoring of atmospheric aerosols by automated scanning electron microscopy**
Stephan Weinbruch, K. Kandler, M. Ebert, Technical University Darmstadt, Germany and L. Schütz, Institute for Atmospheric Physics, Germany
- 12:30-13:00: **Hygroscopic properties of individual aerosol particles from aluminium smelter pot rooms**
Nathalie Benker, M. Ebert, S. Weinbruch, G. Miehe, Technical University Darmstadt, Germany, Y. Thomassen, D. G. Ellingsen, National Institute of Occupational Health, Norway, P.A. Drabløs, Norsk Hydro, Norway
- 13:00-16:00: **Lunch and outdoor activities**
- 16:00-17:00: **Poster viewing, exhibition, coffee**
- 17:00-17:30: **Evaluating the environmental risks of particulate matter using SEM/EDX and micro Raman spectrometry**
Anna Worobiec¹, Elzbieta Stefaniak¹, Larisa Darchuk¹, Allan Brooker² and René Van Grieken¹, ¹Micro and Trace Analysis Centre, Department of Chemistry, University of Antwerp, Belgium, Renishaw plc, Spectroscopy Division, Wotton-under-Edge, England

17:30-18:00: **Bioaccessibility studies of welding fumes**
Balázs Berlinger^{1,2}, Miklós Náráy¹, Dag G. Ellingsen² and Yngvar Thomassen²
¹Hungarian Institute of Occupational Health, Budapest, Hungary
²National Institute of Occupational Health, Oslo, Norway

18:00-19:30: **Short courses**

20:00: **Dinner**

Wednesday, January 30:

Session III: Progress in sampling and characterisation of exposure (cont.)
Chairman: Dietmar Breuer

08:00-08:30: **Permeation measurements of mixtures and products using automated solid-phase microextraction**
Christoph Emmel and Christian Reim, BG BAU, Berufsgenossenschaft der Bauwirtschaft, Germany

08:30-09:00: **Measurement of emissions of volatile organic compounds from laser printers**
Wolfgang Lanters, Dietmar Breuer, Thomas von der Heyden, Hartmut Georg, BGIA - Institute for Occupational Safety and Health of the German Social Accident Insurance, Germany

09:00-09:30: **Gabie and Perkin Elmer passive sampler used to assess short term exposure limits. Laboratory and field validations**
Eddy Langlois, Institut National de Recherche et de Sécurité, France.

09:30-10:00: **Evaluation of airborne lead levels in storage battery workshops and some welding environments in the Kumasi metropolis in Ghana**
Emmanuel Dartey, A A Adimado and K T Djang-Fordjour, Kwame Nkrumah University of Science and Technology, Ghana and College of Agriculture Education, Ghana

10:00-10:30: **Problems of exposure assessment of volatile organic compounds by processing plastic materials**
Pavels Sudmalis, Anita Pike, Jurijs Shvedovs, Marite Arija Bake, Nina Rusakova, Rita Antonevica Institute of Occupational and Environmental Health, Latvia

10:30-11:00: **Coffee, exhibition**

11:00-11:30: **Exposure to quartz at the workplace**
Rainer Van Gelder, Stefan Gabriel, Markus Mattenklott, Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung, Germany

11:30-12:00: **Biological monitoring for MbOCA; past, present and future**
John Cocker, Kate Jones, Kevin McNally, Peter Baldwin, Health & Safety Laboratory, UK, John Cain, Health & Safety Executive, UK

Session IV: Indoor and ambient air chemistry and characterisation

Chairman: Alan Howe

12:00-13:00: **Multifaceted approach to understanding indoor air quality**
Ray Wells, Stacey Anderson, Leon Butterworth, Mike Flemmer, Crystal Forester, Jason E. Ham, Joel Harrison, Laurel Jackson, Bruce Pacolay, National Institute for Occupational Safety and Health (NIOSH), USA

13:00-16:00: **Lunch and outdoor activities**

16:00-16:30: **Exhibition, coffee**

16:30-17:00: **Use of mass spectrometry for determining microbial toxins in indoor environments**
Lennart Larsson, Lund University, Sweden

17:00-17:30: **Wipe sampling - a tool for assessing drug aerosol deposition in hospitals**
Olle Nygren and Hanna Söderström, Umeå University, Sweden

17:30-18:00 **Application of a DNA (quantitative PCR)-based method of mold analysis, to create a standardized bio-monitoring process for indoor molds and the creation of the environmental relative moldiness index (ERMIsm)**
Douglas Irving, Roche Diagnostics Corporation, USA, Stephen Vesper, US Environmental Protection Agency, USA

18:00-19:30: **Short courses**

19:30-20:15: **Exhibitor's cocktail**

20:15: **Conference dinner**

Thursday, January 31:

Session IV: Indoor and ambient air chemistry and characterisation (cont.)

08:30-09:00: **Validation of NO₂ diffusive samplers in an ambient air monitoring network**
Wendy Swaans, E Goelen, Flemish Institute for Technological Research (VITO), Belgium, P Van Avermaet, E Roekens, V Keppens, Flemish Environmental Agency (VMM), Belgium

- 09:00-09:30 **Pilot studies of passive sampling method for ambient NO₂ measurements in Yekaterinburg, Russia**
Natalya Yushketova, Vassily Poddubny, Yuri Markelov, Institute of Industrial Ecology of Ural Branch of Russian Academy of Sciences, Russia
- 09:30-10:00: **The use of passive samplers to determine levels, and exposure on children, of 1,3-butadiene and benzene in Mexico City metropolitan area**
Bo Strandberg, Pernilla Bohlin, Göteborg University, Sweden, Olf Herbarth, University Leipzig, Germany, Kevin C. Jones, Lancaster University, UK, Jephthe Cruz, Horacio Tovali, UNAM, Mexico
- 10:00-10:30: **Atmospheric deposition of metals around some industrial plants in Norway studied by moss analysis**
Eiliv Steinnes, Norwegian University of Science and Technology, Trondheim, Norway
- 10:30-11:00: **Coffee**
- 11:00-11:30: **The use of polyurethane foam passive samplers for monitoring of indoor and outdoor air levels of persistent organic pollutants**
Pernilla Bohlin, Bo Strandberg, Göteborg University, Sweden, Kevin Jones, Lancaster University, UK, Horacio Tovalin, UNAM, Mexico
- 11:30-12:00: **A simplified sampling design for studying chemical variability of Bromeliad leaves**
Elvis J. De França, Elisabete A. De Nadai Fernandes, Camila Elias, University of São Paulo, Brazil
- 12:00-12:15: **Closing remarks**
- 12:15: **Lunch**

Poster Presentations

- 1 Database of international limit values for workplace air**
Dietmar Breuer, BGIA - Institute for Occupational Safety and Health of the German Social Accident Insurance
- 2 Trichloroamines in German indoor swimming baths - results of a nationwide measurement programme**
Dietmar Breuer, Carina Engel, BGIA - Institute for Occupational Safety and Health of the German Social Accident Insurance, Germany, Robert Kellner, German Social Accident Insurance, Germany
- 3 Dust exposure in indoor climbing halls**
Stephan Weinbruch, T. Dirsch, and M. Ebert, Technical University Darmstadt, Germany
- 4 Chemical characterization of water-soluble ionic species in PM₁₀ in the ambient air over Northern Belgium**
Agnieszka Krata, László Bencs, Anna Worobiec, René Van Grieken, University of Antwerp, Belgium, Jordy Vercauteren, Edward Roekens, Flemish Environmental Agency (VMM), Belgium
- 5 Aerosol and gaseous pollutant investigations in the field of cultural heritage research**
V Kontozova-Deutsch, R Van Grieken, University of Antwerp, Belgium, F Deutsch, Flemish Institute for Technological Research (VITO), Belgium
- 6 Investigation into the levels of NO₂, SO₂ and O₃ using passive samplers in the ambient air of Dar es Salaam, Tanzania**
Albert G. Mmari, Tshwane University of Technology, South Africa and University of Dar es Salaam, Tanzania, Agnieszka Krata, René Van Grieken, University of Antwerp, Belgium, Sanja S. Potgieter-Vermaak, University of Witwatersrand, South Africa
- 7 Development of measuring methods for biological monitoring of occupational exposure**
Ferenc Garay, Gyula Farkas, Timea Csiki, Miklos Naray, Hungarian Institute of Occupational Health
- 8 Ecological and biochemical principles of an elements composition estimation of an agriculture landscape**
Svetlana Zamana, Sokolov L.V., Fedorovsky T.G. , Sokolov S.A.
State University of Land Use Planning, Moscow, Russia
- 9 Portable nanoparticle aerosol monitor "nano check"**
Friedhelm Schneider , Grimm Aerosol Technik GmbH, Ainring, Germany

10 A control-based biological monitoring guidance value for PAHs and a follow-up study of exposure in UK workplaces

John Cocker, Kate Jones, Andrew Easterbrook, Chris Keen, Health & Safety Laboratory, UK, James Wheeler, Health & Safety Executive, UK

11 Biological monitoring: a tool to aid the assessment of dermal exposure

J Cocker, K Jones and M Roff, Health & Safety Laboratory, UK

12 The role of interior textiles in environmental tobacco smoke exposure

Malgorzata Cieslak, Textile Research Institute, Lodz, Poland, Hubert Schmidt, Radoslaw Swiercz, Wojciech Wasowicz, Institute of Occupational Medicine, Lodz, Poland

13 The role of breath sampling as a tool for biological monitoring in occupational hygiene applications

Lara Kelly, Elizabeth Woolfenden, Markes International Ltd, UK, John Cocker, Kate Jones, Health & Safety Laboratory, UK

14 RFID tagging for failsafe tracking of sorbent air monitoring tubes

E Woolfenden, N. Watson and L Kelly, Markes International Ltd, UK

15 Sampling method for simultaneous measurement of aerosols, inorganic acids and gases in workroom air

Lars Jordbekken, Nils Petter Skaugset and Yngvar Thomassen
National Institute of Occupational Health, P.O. Box 8149 Dep., N-0033 Oslo, Norway

Development of experimental methods for studying inhalability and personal sampler performance for aerosols in ultralow-wind-speed environments

Darrah K. Schmees, Yi-Hsuan Wu, and James H. Vincent, University of Michigan, Department of Environmental Health Sciences, School of Public Health, Ann Arbor, MI 48109, USA; Sigurd Andersen, Engineering Laboratory Design Inc., Lake City, MN 55041 USA; and Richard Burke, Measurement Technology Northwest, Seattle, WA 98199, USA.

Interest continues in the development of health-related particle size-selective criteria for occupational aerosol sampling and standards as the various standards-setting bodies – such as ISO, CEN and ACGIH – strive to achieve a framework that is truly relevant to actual human exposures in workplaces. One aspect where questions persist is *inhalability*, the efficiency with which people inhale particles through the nose and mouth as they breathe. Although a great deal of research has been carried out over many decades to acquire relevant scientific data, and these have been applied to the development of criteria, there remain some significant gaps. Most previous experiments were conducted in wind tunnels for windspeeds greater than 0.5 m/s. But results from studies in calm air chambers (for essentially zero windspeed) are being discussed as the basis of a modified criterion. But information is lacking for windspeeds in the intermediate range, which – it so happens – pertain to most actual workplaces.

With this in mind, we have developed a new experimental system to assess inhalability and personal sampler performance for aerosols with particle aerodynamic diameter within the range from 6 to 90 μm for ultralow-wind-speed environments from about 0.05 to 0.5 m/s. In this range of conditions of particle size and windspeed, controlled aerosol experiments are very difficult to perform, most notably with respect to the problem of achieving uniform spatial distributions of both test aerosols and air velocity. In the work reported in this paper, we have addressed these in a new, custom-designed experimental facility. It is based on a novel wind tunnel design that provides stable and controllable low-turbulence air movement, and allows for the delivery of test aerosol to the working section both from upstream (as in conventional wind tunnel experiments) and from above (as in calm air studies). In this system, losses by elutriation of particles that are being convected in the horizontal aerosol flow are compensated by particles entering from above by gravitational settling.

An important feature of the new facility is the life-sized, breathing mannequin that contains physical means to achieve any combination of mouth and nasal inspiration and expiration, and allows any desired relevant breathing flowrate and pattern by means of an external computer-controlled breathing simulator. Special steps were taken in the detailed design to ensure that particles may be collected during the inspiration phase of the breathing cycle and that the air during the expiration phase re-enters the breathing zone through a separate pathway (in order to avoid re-entrainment of collected particles). The mannequin itself was heated (to body temperature) to allow for the possibility that, at such low windspeeds, the overall air movement may be influenced by updrafts associated with the enhanced buoyancy of warm air near the body of the mannequin.

The new experimental system has been commissioned and calibrated. Experiments have been carried out to determine the role of expired air and body heat on the time-dependent flow near the mannequin which might be expected to influence the transport, and hence inhalation, of particles. These show that such effects may be expected for some parts of the ranges of conditions studied. Experiments to determine both inhalability and the efficiencies of a range of selected personal aerosol samplers mounted on the mannequin are about to begin.

The successful development of this novel experimental facility paves the way for an important new series of experiments to evaluate inhalability under realistic workplace conditions.

Online monitoring of VOC by proton-transfer-reaction mass spectrometry (PTR-MS)

Armin Wisthaler and Armin Hansel

Institute of Ion Physics and Applied Physics, University of Innsbruck, Technikerstrasse 25, A-6020 Innsbruck, Austria

Proton-Transfer-Reaction Mass Spectrometry (PTR-MS) is a highly sensitive, real-time analytical technique for detecting volatile organic compounds (VOCs) in air, which was developed in the mid-1990ies in the laboratories of the Institute of Ion Physics at the University of Innsbruck. PTR-MS combines the concepts of soft, non-fragmenting chemical ionization (via proton transfer reactions with H_3O^+ reagent ions) and of highly sensitive and quantitative product ion formation in an ion flow drift tube.

Since its inception PTR-MS has become a leading technology in the on-line VOC analysis, spanning a number of research fields that include environmental chemistry, food science, and life sciences. Selected studies on the long-range transport of atmospheric pollutants and on ozone-induced indoor air chemistry will be presented.

A series of recent technical improvements have greatly enhanced the instrument's analytical capabilities. A 5 to 10-fold increase in sensitivity has been obtained with current detection limits ranging from 10 to 100 pptV (1 sec signal integration). The PTR-MS response time has been lowered to about 150 ms, making it one of the fastest currently available VOC sensors. The implementation of sophisticated mass spectrometric equipment (time-of-flight MS, triple quadrupole MS) has led to a gain in duty cycle and in analyte specificity (MS/MS capability). Optimized modes of PTR-MS operation have been developed for the detection of gas-phase ammonia and formaldehyde. An overview of recent technical advances in PTR-MS will be given.

Glyoxal-DNA adducts as biomarker candidates for determination of glyoxal exposure

R. Olsen^{1,2}, P. Molander^{1,2}, S. Øvrebø¹, E. Lundanes², T. Greibrokk²

1) National Institute of Occupational Health, P.O. Box 8149 Dep, N-0033 Oslo, Norway

2) Department of Chemistry, University of Oslo, P.O. Box 1033 Blindern, N-0315 Oslo, Norway

Humans are potentially exposed to a wide variety of chemical substances in their working environment. Exposure for several of these compounds can represent a health risk for the workers, and monitoring of hazardous substances in workroom air or as biomarkers in biological fluids is thus important to industrial hygiene.

The aldehyde glyoxal is widely used as industrial chemical in textiles, organic synthesis, glues, lea roofing materials, adhesives, biocides, permanent-press fabrics, embalming fluids, leather tanning, paper coatings, and as deodorizing agent in the crude oil and gas industry. Thus, occupational exposure to glyoxal is likely in several industries.

Humans are sensitive to exposure for glyoxal, and direct contact with glyoxal can irritate and affect the skin, while exposure to glyoxal vapor can causes eye, nose and throat irritations. In addition, glyoxal has a carcinogenic potential, due to the adduct binding properties with DNA.

There is an increasing interest in using biomolecule adducts as biomarkers of exposure for genotoxic chemicals. Biomolecule adducts represents the biological effective dose, which is the dose that evades the metabolic detoxification and penetrates to the biologically significant sites in DNA. The biological effective dose is assessed by determining the amount of the parent compound or metabolite(s) interacting with cellular macromolecules, e.g. DNA, RNA, and proteins, to form adducts. DNA adducts are considered as selective biomarkers because they reflect the chemical structure of the parent compounds or the reactive electrophilic metabolites formed during biotransformation.

This lecture will describe our work on glyoxal-DNA adducts and the development of a method for sensitive determination of a glyoxal-DNA adduct biomarker candidate by column switching capillary liquid chromatography coupled to micro-electrospray ionization mass spectrometry.

Chemical markers of microbes in exposure assessment

Anne Hyvärinen, Hanna Vehosmaa and Aino Nevalainen
National Public Health Institute, Kuopio, Finland

Chemical markers of microbes are compounds existing only in the cells of micro-organisms and hence represent a tool to measure microbial exposure. Ergosterol is a common fungal membrane lipid that is widely used as a marker of fungal biomass. 3-Hydroxy fatty acids, are considered to indicate the amount of LPS (lipopolysaccharide) and hence gram-negative bacteria. Muramic acid is a marker of peptidoglycan, which is a major cell wall component of bacteria, especially gram-positive bacteria. These compounds are analyzed with gas chromatography-tandem mass spectrometry (GC-MS/MS). Microbial levels in indoor air have remarkable spatial and temporal variation. Hence, the emphasis of development of microbial exposure assessment relies more on dust samples, since those are considered as integrated samples over longer time period. Dustborne microbial levels, however, are affected by multiple factors, which should be known for both exposure and epidemiological purposes.

Our aim was to determine these factors that influence the levels of chemical markers in dust. In addition, we studied the association between chemical markers and childhood asthma. Determinants of chemical markers in dust were studied in two studies: in a asthma-case-control study with 36 new asthmatics aged 1-6 years and 36 matched controls and in a birth cohort of 212 newborns living either in farming or rural home. All homes were visited by trained civil engineers for the inspection of moisture damage and vacuum cleaner dust bags were collected from each home. Ergosterol, 3-OHFAs and muramic acids in dust were determined with GC-MS-MS. In linear regression, home characteristics explained 19-48% of the variation in levels of different microbial groups. In the crude analysis, the factors affecting the microbial levels in dust were quite similar in both studies. The variables remaining in the final models were, however, mostly different in these two studies. Higher ergosterol levels in dust were associated with livestock in both studies. In addition, regular use of fireplace, cleaning area rugs outside and moisture damage of the house increased ergosterol levels. Increase in levels of 3-OHFAs was associated with moisture damage and having livestock in both studies. Higher levels were associated with eg. area of the dwelling, having a open compost outdoors and not changing clothes used in barn before coming inside. In addition, excellent cleanliness of home, having both mechanical exhaust and supply air and not having a fireplace decreased the levels of 3-OHFAs.

The levels of muramic acid were explained significantly by construction year, changing of clothes used in a barn before coming inside, outdoor conditions and also moisture and mould problems. Higher levels of ergosterol (OR=1.87, 95% CI=0.69-5.01) increased some, but not significantly the risk of developing asthma. Microbial levels in vacuum cleaner dust could be explained relatively well with home characteristics. A marginal association between childhood asthma and dustborne ergosterol was shown despite the low number of subjects.

Spatial mapping of atmospheric pollutants for European scale population exposure assessments

Bruce Denby¹, Jan Horálek², Frank de Leeuw³, Peter de Smet³, Pavel Kurfurst² and Jaraslov Fiala⁴

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Ambient air quality still remains an environmental and health problem throughout Europe. Though much has been achieved in the past decades there still remains a number of outstanding problems. In recent years the levels of particulate matter and ozone have not significantly decreased. To provide support to both policy development and public information it is necessary to spatially assess the exposure levels of the European population and its ecosystems to these pollutants.

This paper describes methodologies used to create pollutant maps for all of Europe at a scale of 10 km. The pollutants include PM₁₀, ozone, NO_x and SO₂ but the focus is mainly on PM₁₀ and ozone. These maps do not include local scale hotspots connected to industry or traffic but rather provide a background level for the population exposure calculations. The maps are constructed using both air quality monitoring and air quality modelling data with the inclusion, in some instances, of other spatially distributed supplementary data such as altitude or meteorological parameters. The combination of both monitoring and modelling data provides a robust and an effective description of the spatial distribution, giving complete coverage over all of Europe. Extensive testing of the applied methodologies has been carried out in order to define the best methods. The methods used include multiple linear regression analysis, kriging and co-kriging and residual kriging with linear regression. The monitoring data used in the mapping is provided from the Airbase database and the air quality model used is the EMEP unified model. In addition to producing maps of concentration, or exceedances of limit values, special attention has also been given to the calculation of their associated uncertainty. These uncertainty maps provide extra spatial information concerning the quality of the assessments and can be propagated further into the population exposure calculations to indicate uncertainties in the exposure levels.

The paper includes a preliminary assessment of exposure and impacts of air pollution in terms of population and ecosystems at risk. For example, we calculate the number of Europeans exposed to annual mean concentrations of PM₁₀ above the European limit value of 40 ug/m³ at 5.2% of the total population in 2004. The estimated number of premature deaths calculated, using 2004 as the reference year, is then estimated to be between 246,000 and 327,000, depending on the choice of natural background concentration. The high end of this range is close to the estimates used in the CAFE strategy.

Maps showing concentration levels, concentration uncertainties, population exposure, and their uncertainty, will be provided in the analysis. This is part of ongoing work carried out by the European Topic Centre for Air Quality and Climate Change for the European Environmental Agency.

Methods for determination of isocyanates and related compounds in air

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The majority of the current/proposed ISO methods for monitoring isocyanates in the workplace are based on the derivatization of isocyanates with amine reagents to form stable non-volatile urea derivatives. After sampling and following a number of extraction and/or preconcentration stages, liquid chromatography is used to separate the urea derivatives.

Isocyanates are highly reactive. If compounds are present in air that can react with isocyanates, these compounds can compete with the derivatization reagent, causing inaccurate analyses. Such compounds are primary and secondary amines, alcohols, water, or other compounds with active hydrogens. Solvent-free sampling may be more affected by competing reactions than wet sampling. Reacting aerosols contain compounds that can compete with the derivatization reagent.

Exposures to isocyanates may result in respiratory disorders and dermal sensitization and are one of the main causes of occupational asthma. Airborne isocyanates in workplace atmospheres can occur both in the gas and particle phase. Polyurethanes start to thermally degrade at temperatures above 150 °C to 200 °C, possibly resulting in the emission of monomeric diisocyanates, monoisocyanates, aminoisocyanates, and amines both in gas and particle phases.

Sampling methods for isocyanates: Impregnated filters, Impinger (and filter), Sorbent tubes, Denuder filter and Diffusive sampling.

Direct reading instruments: Paper tape instruments are available where air is sampled continuously on a reagent impregnated paper tape, however, measurement uncertainty may be large. Ion mobility spectrophotometers are also used for the online analysis of isocyanates in the vapour phase.

Standard methods and methods that are in progress to be ISO standards: The di-n butyl amine (DBA) method (ISO 17734-1 & ISO 17734-2): The sampler consists of an impinger containing a toluene solution of DBA with a glass-fibre filter placed in series after the impinger. Solvent-free sampling is performed using a sampler consisting of a tube with an inner wall coated with a filter, coupled in series with a filter; The 1-(2-methoxyphenyl) piperazine (MP) method (ISO 16702 – 1): The sampler consists of an impinger containing a toluene solution of MP with an MP coated filter placed in series after the impinger. Solvent-free sampling is performed with a glass-fibre filter coated with MP. The 1-(9-anthracenyl-methyl) piperazine (MAP) method (ISO 17735 under preparation), the sampler can consist of a MAP-impregnated filter, an impinger containing a solution of MAP in butyl benzoate, or an impinger followed by an impregnated filter. The Double-filter method is a two-stage filter sampler (ISO 17736 under preparation). The first stage is a polytetrafluoroethylene filter to trap airborne particles (isocyanates are subsequently reacted with MP. The second stage consists of a glass-fibre filter (GFF) impregnated with 9-(methylaminomethyl) anthracene (MAMA) positioned after the PTFE filter to collect isocyanate vapour.

Biological monitoring for isocyanates: A guidance value and its application

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Isocyanates are one of the major causes of occupational asthma in the UK, with vehicle spray painters at greatest risk. Biological monitoring is a simple and effective way of assessing exposure, particularly where control of exposure relies on respiratory protection. Free biological monitoring was offered to spray painters as part of comprehensive training at Safety and Health Awareness Days (SHADs). The aim was to help them monitor their own exposure and controls but also to provide data for the Health & Safety Executive (HSE) to monitor exposure and the effectiveness of the training.

Urine samples were hydrolysed to release isocyanate-derived diamines from conjugates. After extraction and derivatisation, the resulting amines were analysed by negative chemical ionisation - gas chromatography - mass spectrometry (NCI-GC-MS). Occupational hygienists assessed exposure controls and collected urine samples from workers in a wide range of workplaces using isocyanates and a biological monitoring guidance value (BMGV) was adopted by HSE based on the 90th percentile of the data (1 μ mol isocyanate-derived diamine/mol creatinine). Paint sprayers around the UK were then invited to one of 28 SHADs near to their workplace to tell them about the hazards of isocyanates, the methods of control and best practice. They were offered a free urine sampling kit and asked to fill in a form describing their work and controls. Biological monitoring results were sent back to them along with a simple interpretation. Any result above the BMGV was followed up with advice to improve controls and another urine sampling kit was supplied.

Urine samples from vehicle paint sprayers who attended the SHADs showed statistically significant ($n = 444$, $p = 0.002$) lower levels of isocyanate-derived diamines than those used to set the guidance value. Sprayers whose first result was positive had significantly lower results in their second sample ($n = 16$, $p = 0.0007$). Urinary isocyanate levels were not related to the volume of paint sprayed or the type of spray space (room, booth, downdraft booth) or the type of RPE used (air-fed half mask, air-fed visor).

Biological monitoring for isocyanates based on the analysis of isocyanate-derived diamines in urine is a useful tool for assessing the adequacy of exposure controls both for individual workers and for the regulator. Educational awareness training can reduce exposure and improve work practices.

Occupational exposure to organophosphates originating from hydraulic fluids

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In the recent years, the press have paid attention to workers exposed to hydraulic fluids, and there have appeared several reports about illness that has claimed to be caused by such exposure. The hydraulic fluids contain among others organophosphates, which is a group of chemicals that includes compounds with large differences in toxicity. For instance, the most toxic compounds among organophosphate pesticides are well known for their neurotoxic effects including acetylcholinesterase inhibition in the nerve cells. For that reason, there has been brought into question whether exposure to organophosphates used in the hydraulic fluids may show similar harmful effects. Nevertheless, there has not been documented that exposure to hydraulic fluids that contain organophosphates is cause to such disease.

On this basis, the National Institute of Occupational Health in Norway (NIOH/STAMI) has started a Ph.D. project to document exposure to organophosphates originating from hydraulic fluids in occupations in Norway. These fluids are mainly used in turbines within aviation and offshore industry. Today, there is no scientific publication that describes such exposure, neither methodology that allows such assessment.

Particularly within aviation, there are several known incidents of pilots reporting such symptoms related to “smoke in cabin” incidents. Due to that the cabin air is bled off the compressed air from the turbines there has been plausible to hypothesize that the source of contamination to the cabin air is addressed to the engines and turbines, especially from hydraulic fluids containing organophosphates.

The aim of the project has been to develop analytical methodology that allows air exposure assessment of selected organophosphates originated from hydraulic fluids. This speech will present the method development in addition to show the application of the methodology within aviation.

International standardisation in the field of workplace air quality

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The health of workers in many industries is at risk through exposure to substances that are hazardous to health. Industrial hygienists and other public health professionals need to determine the effectiveness of measures taken to control workers' exposure and this is generally achieved by making workplace air measurements.

The International Organisation for Standardisation (ISO) has therefore been working to publish standard methods for making measurements of exposure to the most important substances used in industry or produced by industrial activity. These standards are of benefit to agencies concerned with health and safety at work; industrial hygienists and other public health professionals; analytical laboratories; and industrial users of hazardous substances and their workers.

This presentation gives an overview of ISO standardisation activity within the field of workplace air quality, focusing on the work of ISO/TC 146/SC 2/WG 2 Inorganic particulate matter, of which the author is the convenor, and indicating how this links with related standardisation work being carried out by other ISO committees, the European Committee for Standardisation (CEN) and ASTM International.

Proficiency testing scheme for the industrial hygiene laboratory performance assessment

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Nowadays, quality assurance is an important part in the environment of analytical laboratories, who need to prove their ability to perform analysis as well to handle routine control as research and development analysis. However, even if standard deviation of an analytical method is relatively easy to evaluate with repetitive analysis of identical samples, bias is sometimes difficult to assess. A proficiency testing scheme is one of the possible and powerful tools to evaluate both bias and dispersion of the analysis. As far as industrial hygiene is concerned, since analytical uncertainty is insignificant with regard to sampling strategy uncertainty, laboratories could be tempted to neglect analytical uncertainty assessment as well.

The department "Métrologie des Polluants" (part of INRS) has been organising proficiency testing scheme since 2002 with interest of giving the most reliable performance assessment to the participant. Parameters of interest are: organic compounds (mono aromatic hydrocarbons and aldehydes), heavy metals, anions, asbestos and crystalline silica.

The originalities which are also the strong points of the scheme are:

- The determination of the "true" value or assigned value : except for asbestos scheme, all the assigned values are determined by a method that is independent from the analytical method to be tested. This independent determination allows insight into the likely bias of the analytical method, as opposed to most schemes that use participant results to calculate assigned value.
- To achieve this independent mean of measure, INRS had to develop original tools for the fabrication of samples : controlled test atmosphere devices for vapour and dust equipped with online measurement instruments, reference filter preparation dedicated automaton.
- The strength of the statistic model which is based on the WASP HSL scheme model, and slightly modified in order to make results more "meaningful" for the participant. We also developed a tool to visualize the results of participants in bias and dispersion contribution.
- Communication with the participants is also an important feature in the development of the scheme; yearly satisfaction queries and global meetings are set up in order to improve technical significance of the scheme and organisation as well.
- A completely computerized system to handle the participant database, the sample database, results treatment and report edition.
- The use of internet facilities to allow the participant to submit the results via a secured website, and in the near future, to make the yearly subscription and to get the individual report.

All these technical and organisational points are detailed in the presentation with photos, descriptions and examples of use.

The technical and organisational strong points of the scheme allow INRS to get accreditation as a proficiency testing scheme provider and to be able to include this activity in the field of its future ISO 9001 certification.

Production of test gases in the ppb range for round-robin tests or quality assurance measures during the measurement of VOCs

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In indoor areas, volatile organic compounds (VOCs) may cause health complaints. The compounds concerned may be numerous and highly diverse; the concentrations of the individual substances however are generally relatively low. The method applied internationally in accordance with ISO 16000-6 specifies 174 substances which must be analyzed at the same time. In the past, quality assurance measures such as round-robin tests for the measurement of VOCs in indoor areas or at workplaces were not available. A particular reason for this is the challenge presented by the production of test gases in the necessary concentrations.

The BGIA test gas stream was therefore modified for the production of test gases in the required ppb-range. A two-stage primary gas purifier, a continuous test-gas generator with multi-stage dilution, a capillary evaporator for low-volatility compounds and an online thermodesorber were installed specifically for these requirements.

Purification of the primary gas proved to be particularly difficult: the available prepurified compressed air contained organic trace impurities which fluctuated over time. The essential requirement, i.e. for the injection into the test gas stream of a primary gas which was constant over time and exhibited the lowest possible contamination, could be satisfied only by catalytic decomposition of the organic residual impurities and with a supplementary adsorber unit. Even with these measures in place, small quantities of organic substances remain present, and the blank readings must still be monitored continuously. Following completion of all modifications, it proved possible to produce test gases with a high degree of reproducibility with substance concentrations in the range from 1 to 500 $\mu\text{g}/\text{m}^3$.

Since 2007, the BGIA has offered round-robin tests for VOCs with on-site sampling in the range from 5 to 50 $\mu\text{g}/\text{m}^3$. The first round-robin tests show that good results are obtained at concentrations of 30 to 50 $\mu\text{g}/\text{m}^3$. At the lower concentration of < 15 $\mu\text{g}/\text{m}^3$, however, the number of participants experiencing deviations from the reference value was substantially higher. The round-robin tests also involved the taking of blank readings prior to the start of test gas metering. Some two-thirds of participants were unable to detect any interfering components; the remaining participants produced blank readings the levels of which could not always be explained. The problem may be caused in this case by the carrier material Tenax TA, which is usually employed.

Conceptual and practical approaches to assessing exposure to nanoparticles

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Assessment of occupational exposure to airborne engineered nanoparticles can build on approaches developed and validated for conventional nanosized particles generated during e.g. welding or handling of fine powders [1]. Conceptual models provide a framework for consistent description and analysis of exposure scenarios. Such models would include particle transport between room air and surface compartments leading to the final inhalation and deposition and uptake of nanoparticles. Coagulation of airborne particles and gastro-intestinal intake of insoluble nanoparticles deposited in the upper airways has to be considered.

Dustiness tests can give useful insight in time dependency of particle release, size distribution, and state of agglomeration of particles during handling of nanosize powders and provide data for exposure risk ranking. Inclusion of such data in Safety Data Sheets would improve the applicability of SDS for exposure control.

Exposure assessment approaches ranging from control banding to exposure modelling have been developed for conventional materials. These concepts can be further developed for describing and analysing exposure scenarios and for identifying control steps for controlling exposure to nanoparticles. Toxicological data suggest that total particle surface area is the relevant dose metric for insoluble particles. This relation can be used as a stop-gap rule for scaling the effectiveness of technical control measures when reducing the diameter of particles of a given origin.

Exposure data are needed as an evidence base for specific guidance to industry on technical prevention needs and their performance. Such data are lacking, in part due to the uncertainty regarding the proper metric and the lack of field-worthy instruments for measuring nanoparticles at work sites. Notwithstanding, to facilitate exposure data collection, storage, and applicability of the data, tasks should be described according to a common task taxonomy. By using a similarity concept, Bayesian updating can be used for extrapolation when no data exist and for sharpening estimates based on few measurement data.

Occupational hygiene assessment of workplaces can follow existing schemes and methods. One exception is that even very high concentrations of nanoparticles may not be visible to the naked eye, and thus sensitive particle detectors have to be used. Using such instruments presents several challenges such as i) presence of a high background concentration of nanoparticles masking those of interest, ii) how to best sample and quantify agglomerates.

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Workplace measurements of ultrafine particles - practical considerations and current experience

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Workplaces with processes, where ultrafine particles like fumes or even engineered nanoparticles with specific functionalities originate, are coming into the scope of industrial hygienists, as the impact of those particles on human health seems to be different from current hazardous substances. Diverse research results indicate that the health effects no longer correspond to the mass dose but probably to the surface area and/or the number concentration, since the particles' behaviour change in the range below approximately 100 nm. This implies a different measurement strategy and the need to use suitable instruments, which were not used so far at workplaces.

BGIA, in conjunction with the German institutions for statutory accident insurance and prevention (Berufsgenossenschaften - BG), carried out a measurement programme at selected workplaces. The aim was to gather and catalogue information on ultrafine particles occurring at different work processes. They comprise workplaces in metal processing like melting, casting, welding, soldering, cutting, laser beam processes, workplaces in glass production, vulcanization of rubber, processes in food industry like bakery or meat smokery, or workplaces on an airport field. The particle size distribution between approximately 10nm and 700nm and the number concentration of these particles were determined. BGIA was equipped with a suitable measurement device (scanning mobility particle sizer - SMPS) for these particular measurements, added with instruments like a cascade impactor or aerosol samplers for the inhalable and respirable dust fraction. The number concentrations in the measurement range varied between approximately 10 000 particles per cm³ in clean areas up to 40 000 000 particles per cm³ in welding plumes. Peaks in particle size varied between a few ten nanometers up to a few hundred nanometers, depending on the degree of aggregation and agglomeration. Measurements on the surface area concentration of ultrafine particles will be added in the future and can be calculated from number size distributions for existing results under certain assumptions like spherical particle size.

Additionally tests on the penetration of ultrafine particles through breathing masks were performed. The institutions for statutory accident insurance and prevention contribute to a helpful discussion on this topic, and the exposure data will be the basis for future toxicological and epidemiological studies. Common measurement and assessment methods have to be defined. The possible methods of prevention will be improved.

An international sampling convention for inhalable dust in calm air?

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The international sampling convention for inhalable dust was originally intended to be for both oral and nasal breathing in both calm air and moving air (≤ 4 m/s). However, since the publication of the results of Aitken *et al.* (1) and Hsu and Swift (2) it must now be considered that there is a difference between inhalability measured in calm and in moving air, and that it in calm air appears to be a difference between oral and nasal breathing. Dai *et al.* (3) repeated the experiments by Hsu and Swift, but with test persons instead of breathing mannequins, and obtained almost identical results.

Determinations by several investigators of air speeds at workplaces have shown that the median and geometric mean speeds are below 0.3 m/s, approximately midrange between calm air and the lowest workable air speed for wind tunnel experiments with mannequins (4-5). Parallel sampling at in-door workplaces with an IOM sampler and a closed-face or an open-face filter holders results in concentration ratios that are significantly higher than those that can be estimated based on sampler efficiencies determined in wind tunnels and measured or guessed particle size distributions for the sampled aerosol. However, when the measured ratios are compared to ratios estimated from sampler efficiencies determined in calm air chambers, the results are much more in line with each other. These results indicate that a sampling convention for inhalable dust in calm air might be more relevant to occupational exposure at in-door workplaces, than the present one determined in wind tunnels.

There are some important inconsistencies between the published data sets (6). E.g. the two reference methods used by Aitken *et al.* and Swift and colleagues, the circling 'pseudo iso-kinetic probe' and the sedimentation cups, do not give similar results. Additionally, Aitken *et al.* found no difference between oral and oro-nasal breathing, whereas there is a big difference between their results for oral breathing and those of Swift and colleagues for nasal breathing. These data indicate that the aspiration efficiency of the nose is much lower than for the mouth for particles exceeding 20 μm . Consequently very large particles aspirated into the mouth, and sampled by e.g. an IOM sampler, might not be aspirated into the nose.

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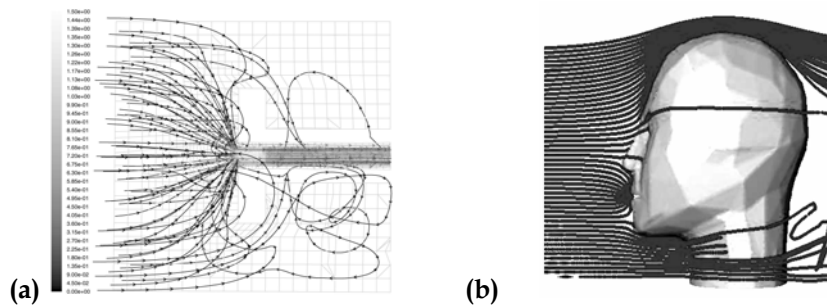
3d dimensional modeling of aerosol samplers for unsteady conditions

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Aerosol samplers are important to environmental and occupational hygiene because of the role they play in the measurement of exposures and the general population to airborne contaminants. This circumstance stimulated construction and of various aerosol samplers. However, despite the wide use of the aerosol samplers, their basic performance characteristics including gas flow dynamics, the sampling and aspiration efficiency are still not fully understood and characterized, especially for unsteady sampling cases. Typical aerosol samplers operate as stationary devices but to describe correctly the real human breathing it is needed to develop the samplers that can work as unsteady devices. It is clear that the development of next generations of sampling devices should be facilitated by the improved knowledge derived from mathematical studies of particle motion in the complex flows about bluff bodies where aspiration occurs.



(a) Particle tracks throw disc-shaped sampler, velocity magnitudes (m/s) are shown in grey scale and (b) particle tracks around a human head due to breathing in moving air

In this work, three-dimensional and unsteady gas dynamics and particle tracks in different aerosol samplers are investigated using CFD modeling. Direct accounting for all the three spatial coordinates and temporal dependences makes the model four dimensional. This approach provides the set of all the key parameters characterizing a sampler. Computational model of human's head was developed in order to define the gas and particle flow pattern. The dummy (see the figure) was heated to body temperature to take into account the convection effects of warm air around the body influencing to aspiration efficiency.

Aerosol sampling by annular aspiration slots

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Annular aspiration slots were studied in laboratory conditions in order to investigate their performance for sampling airborne particles. The aspiration sampling efficiency has been measured in a wind tunnel facilities as a function of particle aerodynamic diameter in various conditions of external wind velocity (from calm air to 4 m.s⁻¹). The flow patterns and particle trajectories were modelled numerically in the vicinity of the sampler. The geometric parameters of annular slots and the aerodynamic conditions of sampling were optimised in order to improve the sampling efficiency. A suitable choice of those parameters lead to the sampling efficiency decreasing very slightly with increasing particle size. Two semi-empirical models of sampling efficiency in wind and calm air conditions were derived and experimentally checked. The omnidirectional annular sampling heads are less sensible to the external wind and their inner particle losses can be minimised. They provide a suitable basis to develop static and personal aerosol samplers for the purpose of aerosol exposure assessment in occupational hygiene and environment.

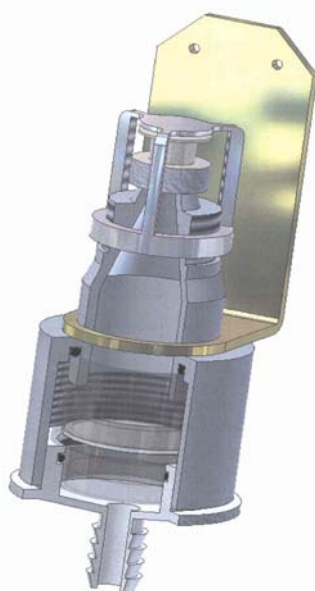


Fig. 1 Prototype of annular aspiration slot personal inhalable aerosol sampler

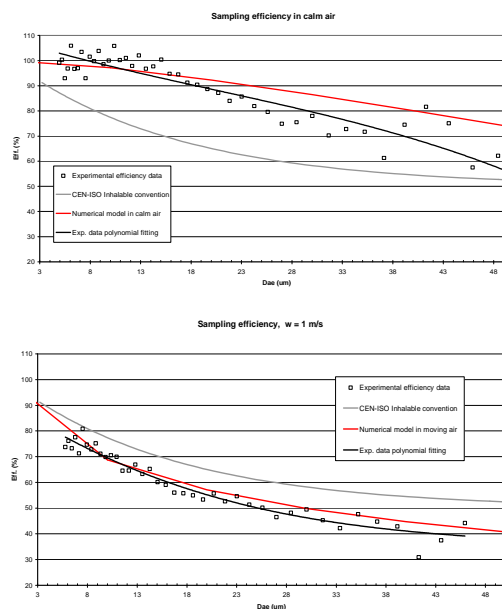


Fig. 2 Sampler efficiency in calm air and in moving air, $w = 1$ m/s

A prototype of a personal aerosol sampler was developed (Fig. 1) and optimised in order to meet the ISO-CEN inhalable aerosol sampling specifications. The overall sampling efficiency of the prototype was studied experimentally in laboratory conditions. The results of the sampling efficiency in moving air and in calm air (Fig. 2) show a fair performance of the sampler which is suitable to the assessment personal exposure of employees to inhalable dust at workplace.

⁺ Jean-François Fabriès passed away working on this study in April 2005

Comparisons of fiber concentrations using different thoracic samplers and slide mounting methods

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The objective of this study is to determine the effect of thoracic sampling against the standard 25 mm cowled sampler (current NIOSH 7400 method) and to compare different mounting methods in the preparation of sample slides. A total of 270 samples were taken from a taconite (iron-ore) processing mill with the CATHIA-T (7 L/min), the GK2.69 cyclone (1.6 L/min), and the cowled sampler (2 L/min) and 308 samples were collected from a tremolitic talc processing mill using those samplers plus a customized GK cyclone operating at 3.2 L/min. Two sample slides were prepared from each filter using different mounting methods, one using the dimethylformamide/euparal (DMF) technique with relocatable cover slip and the other using the acetone/triacetin (AT) technique with clear cover slip (NIOSH standard method). Two counters examined the prepared slides using NIOSH 7400 counting "A" rules.

For both sets of field samples, the overall coefficients of variations (CVs) within- and between-counters, and between two different microscopes were lower than 0.17 and found to be acceptable compared to the overall CV (0.46) for the NIOSH 7400 method. The overall fiber concentrations (FCs) at both mills were lower for the CATHIA-T than the cowled sampler (CATHIA-T/Cowled = 0.63 for the taconite mill and 0.43 for the talc mill). The overall FCs for the GK2.69 were higher for the taconite mill (GK2.69/Cowled = 1.66) and lower for the talc mill (GK2.69/Cowled = 0.68) than the cowled sampler. The customized GK sampler produced almost the same sampling efficiency as the cowled sampler (Custom GK/Cowled = 1.00) in the talc mill. The size distribution of the fibers being sampled was the main difference between the two processing mills. Fibers at the talc processing mill had a higher proportion of fibers wider than 3 μm and longer than 10 μm compared to the taconite mill. The sample slides prepared by DMF technique showed consistently higher concentrations than those by AT method for all samples collected from the taconite mill ($\text{FC}_{\text{DMF}}/\text{FC}_{\text{AT}} = 1.83$). It is possible that some fibers are blown off in the acetone treatment step.

The CATHIA-T sampler and the GK2.69 cyclone may have a potential advantage in screening coarse particles. However, the customized GK cyclone and different mounting techniques in sample slide preparation need to be evaluated in other environments.

Monitoring of atmospheric aerosols by automated scanning electron microscopy

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Monitoring of the chemical composition of particulate matter (PM) is usually performed with bulk analytical techniques. Most of the bulk techniques are cheap and fast making them especially well suited for long-term studies. However, automation procedures were developed in recent years for particle characterization by scanning electron microscopy, and it is, thus, possible to investigate a large number of particles (samples) in a relatively short time. Consequently, scanning electron microscopy is now an interesting alternative for monitoring purposes.

Successful application of scanning electron microscopy to monitoring atmospheric aerosols requires state of the art instruments with (a) field emission gun electron source for high spatial resolution, (b) low sample chamber vacuum in order to avoid substantial loss of volatile components, and (c) thin-window X-ray detector for analysis of light elements. In addition, special emphasis has to be placed on optimizing particle sampling (sampling time, substrates etc.).

In the present contribution, we want to illustrate with two examples the suitability of automated scanning electron microscopy for monitoring particulate matter. First, we will present results from a field campaign at the island of Tenerife (Spain) where the chemical composition of Saharan mineral dust was investigated. Based on the calcium concentrations it is possible to determine the source regions of the aerosol particles. High calcium concentrations in the aerosol particles are related to high calcite concentrations in the soil of the source region. In addition, it was possible to detect the presence of thin surface coatings of sulfate on a large number of particles (> 18000) by investigating the scaling behavior of various element signals with the particle size. There is currently no other technique which allows detection of thin surface coatings (on the order of 100 nm) on such a large number of particles.

In the second example, results from aerosol monitoring at an industrial site in the city of Duisburg (Germany) will be shown. Based on the chemical composition and morphology, it was possible to differentiate different particle groups including metallic and oxidic fly ashes, soil particles (e.g., silicates, oxides), sea salt, soot, secondary aerosol. Automated characterization of more than 40000 particles together with the analysis of meteorological parameters (e.g., wind direction) allowed to quantify the contribution of various sources (e.g., industry, traffic, natural sources) to the aerosol composition.

Hygroscopic properties of individual aerosol particles from aluminium smelter potrooms

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Aerosol particles with aerodynamic diameters between 0.1 and 10 μm were collected in two aluminium smelter potrooms with different production processes (Søderberg and Prebake process). Particles were sampled on Cu foils with a two stage cascade impactor. Size, morphology and chemical composition of approximately 1000 particles were investigated by environmental scanning electron microscopy in the low vacuum mode using a FEI Quanta 200 FEG instrument (equipped with an energy-dispersive X-ray detector). Severe beam damage of the particles prevented the use of automation procedures, i.e. all analyses were carried out manually.

The hygroscopic behavior of the particles was studied in the same instrument at a temperature of 5 °C and a relative humidity (RH) up to 100 % (for technical details see Ebert et al., 2002). Hygroscopic properties of aerosol particles are important for exposure assessment, as they influence the deposition in the human respiratory tract. In contrast to particles consisting of a single phase, the hygroscopic behavior of complex agglomerates (mixtures of various phases on a nanometer scale) cannot be predicted from their chemical composition. Therefore, the hygroscopic behavior of individual particles was studied in situ by environmental scanning electron microscopy.

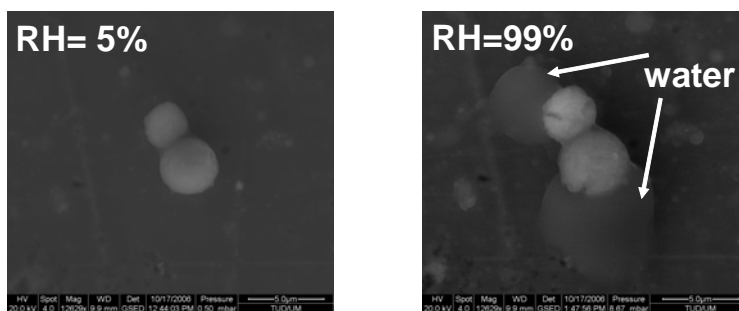


Fig. 1: Secondary electron images of Na, Al, F-particles at low and high RH

Particles containing sodium, aluminium, fluorine, and oxygen are the dominant particle group. In addition, carbonaceous particles with high oxygen content were also observed frequently. As we collected the particles directly above the melt, the abundance of the different particle groups is different from the findings of Höflich et al. (2005) who performed personal sampling in the same two potrooms. All particles consisting of Na, Al and F developed a small water film or large water droplets (Fig. 1) at high relative humidity (RH > 95 %), indicating the ubiquitous presence of surface coatings of soluble material. Due to the high solubility of HF in water, these observations provide an opportunity to transport HF deep into the lung.

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Evaluating the environmental risks of particulate matter using SEM/EDX and micro Raman spectrometry

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A more advanced and powerful tool for compositional analysis of individual particles is a conjunction of both a molecular and an elemental technique, such as micro-Raman spectrometry (MRS) and scanning electron microscopy coupled with energy-dispersive X-ray detection (SEM/EDX). Successful, parallel application of these two methods seems to open up new insights into the structure of particles. Single particle analysis by SEM/EDX has been developed for over 20 years and has extended our knowledge on the elemental composition of micrometer-size objects. The possibility of fully automated analysis of a large number of objects, so called Computer Controlled SEM/EDX, and a subsequent quantification procedure (the reverse Monte Carlo quantification) let us get an insight into particulate matter. MRS has just been involved in the investigation of single particles in order to complement elemental composition information with a molecular makeup. However, a number of fundamental aspects arose during parallel and simultaneous analysis by means of the two techniques:

1. Sample preparation for the simultaneous SEM/EDX/MRS analysis. When the simultaneous analyses by SEM/EDX and MRS are considered, the correct choice of the collection surface plays a crucial role, especially in case of atmospheric particles with unknown or unpredictable composition. From the results so far, it appears that Ag foil is the most versatile for all kinds of particulate matter. It does not contribute to the Raman signal and also gives some enhancement effect.

2. Particle recognition techniques. For the combined SEM/EDX/MRS analysis, a relocation of particles plays a crucial role. The clue is to get both elemental and molecular information coming from the same feature, but with the help of the two images constructed in a completely different way. One of the solutions is the application of Cu grids used in transmission electron microscopy.

3. Analytical sequence of SEM/EDX and MRS analysis. For subsequent analysis by SEM/EDX and MRS as stand-alone instruments, when both elemental and molecular data from the same particle is required, the sequence of the analysis plays an important role. This is particularly crucial for amorphous carbon detection.

4. Beam damage and micro-chemical reactions. The conventional damage (e.g. evaporation) of individual particles is rather under control, as long as the measurements are done with separate SEM/EDX and MRS techniques. Under the laser beam in the ambient atmosphere, no crucial evaporation of particles was detected so the Raman spectra could be recorded with sufficient quality. However, damage to some particles under the laser beam was observed in vacuum. The interfaced combination of two well-established technologies, SEM/EDX and MRS, will result in a powerful new technique and will transform the SEM into a more prevailing tool for materials characterisation. Such a hybrid system allows morphological, elemental, chemical and physical analysis without moving the sample between two instruments.

The application of combined SEM/EDX and MRS analysis was tested in case of fine atmospheric particulate matter. The differences among e.g. welding particles of the same elemental composition with respect to their molecular properties were detected. The MRS analysis revealed that Fe-O-rich particles were goethite, hematite and magnetite. This important information could be subsequently used in research on e.g. the optimisation of the air filtration processes. Another example refers to C-N-O-S-rich particles. So far, the determination of their chemical structure was ambiguous, because they could be considered as S-containing organic species as well as agglomerates of ammonium sulphate and ammonium nitrate particles with a layer of soot. Due to MRS, the correct specification of this type of airborne aerosols is now conclusive.

Bioaccessibility studies of welding fumes

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For the better understanding of the biological effects of welding fumes there have always been a high demand for bioaccessibility studies. The presented work is the first step in a comprehensive study, which can extend our present knowledge about welding fumes to make the efforts more effective in the protection of welders' health. This study consists of many different parts; all of them are to examine different aspects. In the presentation the concept will be introduced and some of the most remarkable results will be highlighted.

Four different welding techniques were investigated during the study: manual metal arc welding (MMA), metal inert gas welding (MIG), tungsten inert gas welding (TIG) and mixed MMA-TIG welding. Each technique was used for stainless steel welding. For the solubility study welding fumes were collected on 5.0 µm PVC membrane filters in batches of 114 using a 'Sputnik' multiport air sampler. For the determination of the mass and elemental distributions as functions of aerodynamic diameters of the particles, samples were collected on plastic substrates by an eleven-stage Berner cascade impactor. Particle size distributions of the welding aerosols were determined by a scanning mobility particle sizer (SMPS) in the range of 10 to 487 nanometers and by a dust monitor and counter in the range of 0.75 to 15 micrometers. Samples were collected for individual particle analysis by transmission electron microscopic (TEM) technique as well.

Three different fluids were applied for the solubility study; deionised water and two kinds of lung fluid simulants: lung epithelial lining fluid simulant (Gamble's solution) and artificial lung lining fluid simulant (Hatch's solution). Extractions were made within a few hours after sampling in 50 mL volume polypropylene centrifuge tubes with 25 mL filter cup inserts equipped with 0.2 µm nylon membrane by adding 10 mL of solution to the PVC filter samples. In order to get sufficient data to calculate dissolution curves, seven different extraction periods were used (0.5, 1, 2, 4, 8, 16, 24 hours), each of them with three replicates. Each tube containing the filter and the extraction solution was placed in a laboratory oven set to a temperature of 37 ± 1 °C for the specified extraction periods. Extractions with deionised water were made at room temperature as well with the same extraction periods as described above. To study the changes in solubility with aging, extractions with water were applied with three replicates and 2 hours of extraction periods 1, 3, 7, 14 and 28 days after fume collections. For the determination of the total amount of metals in the welding fume samples, some of the filters were digested in Teflon autoclaves with a mixture of aqua regia and hydrofluoric acid.

The metal contents of the extracts and the digests were measured by inductively coupled plasma optical emission spectrometry (ICP-OES).

The most obvious observation of the solubility results is that each metal may have a very different solubility even with a different dissolution curve with respect to the welding technique, the extraction fluid and the extraction time.

Permeation measurements of mixtures and products using automated solid-phase microextraction

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Permeation of substances through materials is an important question for personal protective equipment. For e.g. chemical protective gloves usually only the permeation characteristics of common substances are examined.

A new sample preparation and analysis method for permeation studies of substance mixtures through membranes based on solid-phase microextraction (SPME), is described. A combination with GC/MS-analysis enables an easy separation and identification of substances in mixtures. As the method is applicable to a broad range of substances without the need of any clean up steps not only known ingredients of products will be detected but also additional unknown compounds.

The GC/MS is coupled with a special auto sampler device for sampling through membranes. Depending upon the substances sampling period varies from a few seconds to several minutes. The sampling intervals are determined by the rate of analysis.

Due to the high sensitivity of the measuring system the main application of this technique are permeation tests of mixtures of low volatile and low soluble compounds in the presence of substances with higher volatility.

The conditions were optimized for permeation tests of sensitizing ingredients of epoxy resins in products (e. g. highly reactive diamines and glycidylethers) and natural substances (e. g. foods).

Measurement of emissions of volatile organic compounds from laser printers

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Laser printers are being used increasingly both at workplaces and privately. Studies have shown that the toners used in laser printers emit volatile organic compounds (VOCs) during the printing process. Brand-new products also emit VOCs even when printing is not in progress.

Manufacturers and consumers obviously have a particular interest in the sale of low-emission equipment. The BGIA has been studying emissions from laser printers for several years. The current test is based upon RAL¹-UZ 122, this regulation serves as the basis for awarding of the "Blue Angel" environment mark, and is also observed within the ECMA-328 standard issued by ECMA International.

To date, over 200 standard laser printers from a number of manufacturers have been studied at the BGIA. VOC emissions are measured qualitatively and quantitatively by means of thermal desorption, GC-MS and GC-FID following adsorption on Tenax TA. The detection limit of the VOCs is 1 µg/m³. For benzene, which must be analyzed separately, the limit is 0.25 µg/m³. For the purpose of testing, the concentrations of 40 calibrated substances are determined, including siloxanes, esters, aromatic and aliphatic hydrocarbons. All further identified substances are measured in terms of toluene equivalents.

The results of the studies show that emissions vary widely from one printer to another. This applies both to the spectrum of the substances, and to the concentrations of the individual VOCs. VOCs frequently detected are toluene, 1-butanol, ethylbenzene, xylenes, styrene and phenol. In addition, siloxanes such as hexamethylcyclotrisiloxane are characteristic constituents of the emissions from a large proportion of the printers.

The majority of printers tested satisfied the requirements of the RAL. Printers which were not awarded the test mark exceeded the permissible emission rate for TVOCs, or were found to emit benzene.

¹ RAL Deutsches Institut für Gütesicherung und Kennzeichnung e.V.

Gabie and Perkin Elmer passive sampler used to assess short term exposure limits. Laboratory and field validations.

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Diffusive sampling is known to be a reliable alternative to the active sampling method of assessing organic compound exposure in workplaces. Based on the principle of molecular diffusion, passive samplers are small in size, lightweight and easy to both use and wear. The passive sampling method can be very convenient for performing long-term monitoring, large-scale exposure assessment or defining homogeneous exposure groups because it is not very expensive and does not require technically trained personnel, unlike active sampling. Many studies have validated the use of passive sampling either in a laboratory generated atmosphere or under the workplace conditions for long-term exposure assessment

Many industrial operations cause large variations in pollutant concentration and workers can therefore be exposed to high concentrations over short periods. Short-term exposure assessment is consequently often more accurate, when operations creating peak exposures are identified. However, hygienists find implementation of this kind of sampling strategy quite difficult using the usual active methods. This context highlights the advantages of passive sampling, as previously described, and passive sampler usage would considerably simplify the sampling procedure.

There is very little available information on the behaviour of sampling systems in peak exposure situations and their capacity for determining pollutant concentration. Under these circumstances, sampling systems are often assumed to be as accurate as in stable, continuous pollutant concentration atmospheres and their performance has seldom been studied in relation to measuring pollutant concentrations featuring sharp peaks. Whilst active sampling works at a constant, established flow rate, passive samplers are known to be subject to a transient period prior to diffusion flow steady state, this transient period corresponds to boundary limit establishment in the diffusion path and depends mainly on the diffusion path length and the nature of the attenuation layer covering the sampler shape. Transient period is related to the sampler geometric parameters, so uptake rates could influence results depending on the total sampling time.

The aim of our study is to investigate the behaviour of two different passive samplers during exposure to pollutant concentration peaks firstly under controlled test atmospheres and then under workplace atmospheres, in paint factories and photogravure workshop. The first sampler is the thermally desorbed Perkin Elmer sampler and the second is the INRS (Institut National de Recherche et de Sécurité)-designed and developed GABIE sampler containing activated charcoal to be desorbed with solvent after exposure. Performance of both these samplers has been compared to reference active sampling.

With both laboratory and field experimentations, the use of GABIE and PERKIN ELMER passive samplers is validated for monitoring not only highly fluctuating atmospheres, but also short-period peak emissions for comparison of concentration values with STEL values. We then propose a suitable strategy, based on simultaneous use of photo ionisation detectors (PID) for following the global concentration trend and determining peak occurrence and a passive sampler for method selectivity in the case of multi-pollution.

Evaluation of airborne lead levels in storage battery workshops and some welding environments in the Kumasi Metropolis in Ghana

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The major sources of lead in the environment that are detrimental to the health of man arise from industrial and other technological uses of lead. Adverse health effects of lead include brain and kidney damage, gastrointestinal distress, slowed cognitive development and reproductive effects of decreased sperm count in animals and man, as well as spontaneous abortion in women (ASTDR, 1992). Industries that use lead containing alloys such as lead-acid battery repairs, electric welding and electronic repair workshops are considered to be important sources of the emission of lead fumes into the general air of the working environment (Abdel Hameed and Khoder, 2000).

This study has been undertaken to determine lead levels in the air in these working environments. Levels of lead in the air were measured in three different workplaces: storage battery repair workshops, electric welding workshops and TV, Video & radio repair workshops situated at Asafo Fitam, Suame Magazine, Tafo and Bantama; suburbs of Kumasi in Ghana. Airborne lead particulates of more than $0.45\mu\text{m}$ in aerodynamic diameter were collected using membrane filters, pore size of $0.45\mu\text{m}$ and diameter of 47mm and liquid bubbler containing 15% HNO_3 was used to collect fumes less than $0.45\mu\text{m}$ in diameter. Collected filters were digested with HNO_3 and analysed using Flame Atomic Absorption Spectrophotometry.

The welding shops recorded mean lead concentrations of $403.10 \pm 40.92\mu\text{g}/\text{m}^3$ at “A” sampling point (close to the emission source and at a height of about 150cm, the breathing zone of workers) and $248.16 \pm 30.23\mu\text{g}/\text{m}^3$ at “B” sampling point (2.5m away from the emission source and at a height of 150cm). The Battery repair shops recorded mean lead concentrations of $1,836.94 \pm 54.60$ and $1,464.79 \pm 49.84\mu\text{g}/\text{m}^3$ at “A” and “B” sampling points respectively. The TV, Video and Radio shops recorded mean lead concentrations of $1,468.62 \pm 81.84$ and $729.90 \pm 60.16\mu\text{g}/\text{m}^3$ at “A” and “B” sampling points respectively. The study found that the levels of lead at all the workshops exceeded the WHO ($50\mu\text{g}/\text{m}^3$), Japanese ($100\mu\text{g}/\text{m}^3$) and Egyptian ($150\mu\text{g}/\text{m}^3$) recommended maximum occupational exposure levels. There is need to set acceptable exposure levels of these toxic compounds at workplaces in developing countries.

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2. Agency for Toxic substance and Disease Registry(ATSDR), (1992). Toxicological profile for lead-draft. Atlanta: US Department of Health and Human Services, Public Health Service.

Problems of exposure assessment of volatile organic compounds by processing plastic materials

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There are enterprises what occupy in different plastic processing works now in Latvia. They produce deferent details for industry and household use: polythenes, bottles, pots, cans, other vessels and details. Mostly they work with different types of polyethylene, polypropylene, polyvinylchloride and polycarbonates. Workers have complains on health disturbances (headache, irritation, tiredness) and stuffy air. From literature we now that the plastic material can emitted by heating up different chemical substances like different hydrocarbons, aldehydes, chloride and others organochlorides and different plasticizers lake phthalic acid esters. The goal of the research was to identify most common pollutants and found best practices of sampling and exposure assessment strategy.

For identification and quantification we use High performance liquid chromatograph Waters "Alliance" with UV detector, Gas chromatographs Varian 3800 and Waters Micromass with MS/MS detector. For the air sampling we compare different air sampling methods. For hydrocarbons we use industrial produced charcoal tubes and passive diffusion monitors and special thermo desorbtion tubes if solvent can disturb identification and quantization of pollutants. For aldehydes we use industrial produced SPE tubes and glass fibre filters with dinitrophenyl hydrazine on them.

We identify aldehydes (formaldehyde, acetaldehyde, propionaldehyde, and butyraldehyde), acetone, ethanol, prophanol, ethyl benzene, xylene, vinyl chloride, bis(ethylhexyl) adipate, bis(ethylhexyl) phthalate and dibutyl phthalate in low concentrations in work place air. The composition and concentration of pollutants strongly depends of plastic material heating temperature.

The results are comparable between different air sampling techniques according to the experiments, and those of concern method depend only of samples taken handy. Our results show, if work place and equipment have enough good ventilation, then concentration of dangerous chemical compounds is under occupational exposure limits (OEL).

Exposure to quartz at the workplace

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Quartz is used as a material in a large number of working processes in various sectors of industry. Released as dust, it is a source of exposure to fine quartz dust. Despite technological advances and considerable efforts to reduce dust, exposure to respirable quartz dust today is still a significant problem. In Germany silicosis is ranking among the occupational diseases with high annual numbers of suspected and recognized cases.

In view of these facts, there was a need for a general review of the quartz situation. Available exposure data should be processed if possible according to branch of industry and field of activity e.g. extraction of quartz sand, extraction and processing of minerals and earths, ceramics and glass industry, foundries, chemical industry or construction industry. The goal of these activities was to support prevention in occupational safety and health. At the same time, it should be possible to refer to the statistical parameters of the measured data to permit data comparability during risk assessment.

Measured values for quartz and respirable dust were recorded over three decades since 1972 in the quality controlled BGMG hazardous substance measurement system, and were entered in the MEGA database of measured data relating to exposure to hazardous substances at the workplace. The sampling was conducted in accordance with BGMG standard procedures in around 8,900 companies. Likewise the standard BGMG procedure was employed for analysis. For quartz analysis, x-ray diffraction was primarily used, and also to a small degree infrared spectroscopy. The measured values for respirable dust were obtained by weighing and β radiation absorption.

Data from some 104,000 measurements comprising both a respirable dust and a quartz measurement value were available. The percentage of quartz was calculated for each pair of measured values. The statistical evaluation of the collected data was carried out with the MEGA^{Pro} software developed at BGIA.

For observation of time trends in the concentration values, the data were subdivided into time periods of 10 or 5 years according to the number of available measurements. The representation of the statistic parameters arithmetic mean, and 10%, 50% and 90%-percentil takes place predominantly in tabular form. For some branches of industry the development of the dust exposition is represented in the course of the time in box plots, in order to emphasize the change of the exposure.

On the basis of these results, the exposure situation over various periods is described to serve as a basis for the management of preventive measures and monitoring of exposure. They can be also used for quantifying past exposure to quartz in the context of cases of suspected occupational disease. By comparisons with a current in-plant state the results could be used for risk assessment.

Biological monitoring for MBOCA; past, present and future

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MbOCA (4,4'-methylene bis(2-chloroaniline)) is a suspect human carcinogen used for manufacturing polyurethanes and epoxy resins. Because MbOCA has low volatility and is readily absorbed through the skin, biological monitoring has been used for many years to assess exposure. MbOCA was a model for biological monitoring guidance values based on the 90th percentile of data from workplaces with good control. This study was one element of HSE's disease reduction programme on carcinogens and aimed to assess current controls and exposure to MbOCA and in addition to use biological monitoring to look at exposure to the isocyanates used with MbOCA.

Health & Safety Executive and Health & Safety Laboratory occupational hygienists visited 20 of the 25 known users and the 2 suppliers of MbOCA (no UK manufacturer). Observations of the processes and assessments of the controls were made. Samples of air, urine, gloves and surfaces were collected to assess exposure to MbOCA. Urine samples were also analysed for isocyanate-derived diamines released by hydrolysis of urinary conjugates.

Urine samples (78) showed that exposure to MbOCA was most likely to occur during casting and moulding. The 90th percentile of urinary MbOCA was 8.8 µmol/mol and only 3 samples (4%) were above the Biological Monitoring Guidance Value (BMGV) (15 µmol/mol). Personal airborne exposures (80) to MbOCA were low with only 13 above the limit of detection and only 2 exceeding the Workplace Exposure Limit (0.5 µg/m³). Surface samples and gloves (n=334) revealed poor handling, poor housekeeping and widespread contamination, suggesting that dermal exposure was significant. One or more isocyanate metabolites were detected in 36 of 76 (47%) urine samples. The most frequently detected metabolites came from toluene diisocyanate and hexamethylene diisocyanate with 8% of the results above the BMGV (1 µmol/mol).

Conclusions: Although urinary MbOCA levels are generally below the BMGV, there is scope to reduce dermal exposure further. The surprise findings were the levels of isocyanate metabolites in urine and, although mostly below the BMGV, they point to a need to control exposure to isocyanates as well as exposure to MbOCA.

Multifaceted approach to understanding indoor air quality

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- 15-23% of new-onset asthma cases in adults are work-related asthma [American Thoracic Society 2004]
- Highest percentage of work-related asthma occurred among operators, fabricators and laborers (32.9%) [Worker Health Chartbook 2004]
- Between 35 and 60 million of the 89 million indoor environment workers have building- related symptoms of eye, nose and throat irritations; headache and fatigue [Mendell 2002]

These points (listed above) impact US businesses in the range of \$20-70 billion annually due to lost productivity and absences from work. Yet, questions still remain: What are the irritants that induce asthma and other building-related symptoms and where do they come from? The answers may come from research in gas-phase and surface-phase chemistries, improved field and analytical sampling methods and mechanism-based toxicology.

The use of terpenes like α -pinene, limonene and α -carene in cleaners and air fresheners can introduce very reactive species into the indoor environment. By investigating the gas-phase chemistry of some of these terpenes, we have shown that they can react rapidly with ozone, hydroxyl radicals and nitrate radicals to form difficult to detect oxygenated organic compounds like aldehydes, ketones and dicarbonyls which may be the irritants partially responsible for the observed increases in work-related asthma.

Derivatization agents, such as PFBHA, have been used successfully to identify many of these oxygenated organic reaction products. Furthermore, the coupling of derivatization and solid-phase microextraction (SPME) has been shown to be a promising method for accurately sampling indoor environments for these reaction products.

A structure reactivity model by Jarvis *et al.* [Jarvis 2005] suggests that oxygenated organic compounds with a combination of two or more carbonyl or alcohol groups could have adverse health effects. Studies exposing primary epithelial lung cells to oxygenated organic reaction products are currently underway in an attempt to identify the mechanisms governing the adverse health effects.

This presentation will report the recent findings on the kinetics and mechanisms of common terpene chemicals, indoor environment sampling techniques, and health effect pathways. The application of the data to indoor air quality will also be discussed.

Use of mass spectrometry for determining microbial toxins in indoor environments

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MSMS strategies for determining mould mycotoxins and bacterial endotoxins in indoor environmental samples are described. For mycotoxin analysis samples (sedimented dust, cultures of dust, pieces of mould-affected building materials) are extracted with methanol, purified, and divided in two parts. One part is analysed directly by HPLC-electrospray MSMS for sterigmatocystin (mainly from *Aspergillus versicolor*), gliotoxin (from *A. fumigatus* and *Penicillium*), and satratoxin G and H (*Stachybotrys chartarum*). The remaining part is used for screening of all macrocyclic trichotecenes that are produced by *S. chartarum* and for detecting trichodermin; here, the methanolic extract is hydrolysed to release verrucarol from any of the different *Stachybotrys* trichotecene structures (at the same time trichodermol is formed from trichodermin), then, verrucarol and trichodermol are converted to heptafluorobutyryl derivatives and analyzed by GC-MSMS in negative ion-chemical ionisation mode. In a study completed recently mycotoxins were found in 45 of 62 studied building material samples visibly colonized by moulds. Mycotoxins were also found in some dust samples that had settled on surfaces above floor level, *i.e.*, on the top of a door frame and a bedroom skirting board, in the same rooms where mould-affected building materials were found to be positive for the same mycotoxin(s).

There are no generally approved analysis methods for bacterial toxins in indoor environments except for the *Limulus* test used for determining endotoxin (LPS). This test, however, determines endotoxins from different Gram-negative bacteria without any distinction. We have during several years developed and applied an MSMS method which takes advantage of the fact that the lipid portion of LPS contains some fatty acids that are hydroxylated in position 3 and typically of 10-18 carbon chain lengths. As a rule there are four moles of 3-hydroxy fatty acids (3-OH FAs)/mole LPS. Samples (building materials, dust) are hydrolysed, purified, derivatized, and analysed for 3-OH FAs (as methyl trimethylsilyl derivatives) by GC-MSMS. Since the LPS of different groups of Gram-negative bacteria may have 3-OH FAs of different chain lengths this type of analysis provides information not only about the absolute amounts of endotoxin in the sample but also on the composition of the Gram-negative bacteria present. Also tobacco smoke contains endotoxin (the 3-OH fatty acids being dominated by 3-OH C_{14:0}) originating from the large amounts of endotoxin in the tobacco. In collaborative studies we found recently that endotoxin subpopulations where 3-OH FAs of shorter chain lengths dominate seem to protect from asthma symptoms whereas endotoxins where 3-OH FAs of longer carbon chain lengths dominate do not.

Wipe sampling - a tool for assessing drug aerosol deposition in hospitals

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Already in the 1970-ies, the risk of exposure to cytotoxic drugs was identified. Studies from that period have not, however, shown a conclusive picture. During the end of 1980-ies and beginning of 1990-ies, there was a development of new analytical methods. It became possible to analyse a number of active cytotoxic substances or markers for these at very low levels. These analytical methods made it possible to study spill and leakage of cytotoxic drugs by sampling specific drugs. In late 1990-ies and onwards attention has also been paid on spill and leakage of other groups of drugs, e.g., antibiotics and other reactive drug compounds. In Sweden, more than 32 000 defined daily doses (DDD) cytotoxic drugs are handled annually in closed medical care. Several of the studies reported in this presentation show that occupational exposure to these drugs does occur, although the drugs are handled inside BSC under strict regulation. About 140 times larger volume of antibiotics (4 500 000 DDD) are handled in closed medical care with very limited regulation. These drugs are normally handled on open benches and with limited safety precautions. Significant larger groups of staff handle antibiotic drugs in much larger areas in medical care facilities compared with cytotoxic drugs. The spill and leakage of antibiotics can, thus, be expected to be at least of the same relative amount, i.e. 140 times more antibiotic than cytotoxic drugs are expelled into the indoor environment in hospitals and other medical treatment facilities. Very little is, however, known about the impact of this spill and leakage.

As a complement to traditional exposure monitoring, assessment of aerosol deposition can be a simple and quick screening method for identifying deposited aerosols. Wipe sampling methods have been developed for collection of drugs from indoor surfaces. These screening methods are rapid, simple and easy to carry out. In this presentation examples of screening studies of drug deposition in hospitals, based on wipe sampling in combination with adequate analytical techniques, are described. The sampling methods used have been validated regarding wipe material, wetting solution, wipe area size, wipe procedure, sample handling and pre-treatment prior to analysis. The validation showed that the methods are adequate for assessment of drug distribution in indoor environments. The wipe methods are quick and user-friendly and their flexibility makes them suitable for monitoring distribution of various drugs in indoor medical environments. The usefulness for various applications have been demonstrated in a number of studies presented. The studies comprise wipe sampling in pharmacies and oncology wards to assess the spatial distribution of the drugs. Studies of spill and leakage from various handling systems are also reported as well as studies of contamination on the outside of drug vials. These studies show that a significant emission of drugs occurs during preparation and that it is possible to assess the spatial distribution of these drugs.

Application of a DNA(quantitative PCR)-based method of mold analysis, to create a standardized bio-monitoring process for indoor molds and the creation of the environmental relative moldiness index (ERMIsm)

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The objective of this study was to apply mold specific quantitative PCR to establish a national relative moldiness index for homes in the U.S.A..

As part of the 2006 US Department of Housing and Urban Development “American Healthy Homes Survey”, dust samples were collected by vacuuming 2 m² in the bedrooms plus 2 m² in the living rooms from a nationally representative 1096 homes in the USA, using the Mitest™ sampler. Five mg of sieved (300 μ pore, nylon mesh) dust was analyzed by mold specific quantitative PCR (MSQPCR) for the 36 water-damage indicator species in 1096 samples.

On the basis of this standardized national sampling and analysis, an “Environmental Relative Moldiness Index” (ERMIsm) for US homes was created with values ranging from about -10 to 20 or above (lowest to highest).

The ERMI scale is useful for mold-burden and exposure estimates in the US and may have applications in Europe as well.

Validation of NO₂ diffusive samplers for use in an ambient air monitoring network

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NO_x emissions result primarily from the combustion of fossil fuels (natural gas, oil and coal). Major sources include traffic and combustion plants such as power plants and industry. Ozone is formed when nitrogen oxides combine with other compounds in the air in the presence of sunlight and heat.

At this moment NO_x is also the most important pollutant in acidifying emission in Flanders. According to the European Directive 2001/81/EC, member states shall limit their annual national emissions of the pollutants sulphur dioxide (SO₂), nitrogen oxides (NO_x), volatile organic compounds (VOC) and ammonia (NH₃) by the year 2010 at the latest. In 2002 the Flemish Environmental Agency (VMM) started up a network for acidic deposition in Flanders. Within this network diffusive samplers are used for NO₂ ambient air measurements because of the low cost and easy use. Several types of NO₂ and SO₂ diffusive samplers are commercially available, most of them using triethanolamine as absorbent. At the start of measurements a combined NO₂-SO₂ Radiello sampler was chosen because of the higher uptake rates resulting in much lower detection limits. After modification by supplier, samplers showed less good agreement with analyzers for NO₂ during some of the field measurements. Therefore the combined NO₂-SO₂ Radiello radial-type diffusive sampler was validated under extreme laboratory conditions. Subsequently the sampler was also compared with 3 other types of samplers (IVL, OGAWA, GRADKO) in a field comparison at two locations Ghent-Mariakerke and Borgerhout in Flanders. During laboratory validation tests a significant effect of temperature and relative humidity on NO₂ uptake rate was observed. High relative humidity (70 to 80%) caused a strong non-reproducible decrease of uptake rate for NO₂ at 24 hour experiments but this effect was not observed at longer exposures except for the tests at -5°C. At the tested temperature below zero in combination with high relative humidity the sampler showed anomalous behaviour for NO₂. The NO₂ accuracy of Radiello samplers was better during field campaigns than during laboratory validation. Results of the overall validation study and further comparison between diffusive samplers are presented in the current presentation.

Pilot studies of passive sampling method for ambient NO₂ measurements in Yekaterinburg, Russia

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Passive sampling method is widely used for monitoring various gaseous atmospheric pollutants. This method is easy to use, low-cost, doesn't require power supply and is proved to be an appropriate tool for multipoint and long-term monitoring. At the same time passive sampling is known to be affected by a number of environmental parameters as well as properties of sorbents used and pollutants sampled.

The objectives of our research are: (1) to study physicochemical processes underlying passive sampling method; (2) to simulate passive sampling process under various environmental conditions; (3) to test passive sampling devices for monitoring gaseous pollutants. The presentation deals with the preliminary results obtained.

In order to estimate influence of fluctuation of concentration, air temperature, wind velocity and different methodological aspects on passive sampler performance, time-dependent diffusion problem and hydrodynamic problem were solved. The simulation showed that under condition of fluctuating concentration difference between time-weighted average concentrations obtained by passive sampler and calculated ones didn't exceed 1%. In some cases the difference resulted from the temperature fluctuations can reach 7.5%, but on the whole, this factor showed to be insignificant. Hydrodynamic problem was solved for steady two-dimensional flow model. It was found that wind induces formation of eddies and that there is a domain inside the sampler in which air velocities exceed or can be comparable with molecular diffusion velocities. Variations of effective diffusion path lengths at different wind speeds and sampler lengths are given. Results of hydrodynamic simulation confirmed those obtained from the experimental studies carried out by other authors.

Pilot measurements of ambient NO₂ concentrations using passive sampling method were performed in Yekaterinburg, Middle Ural. Devices used in this work were diffusion tubes, with triethanolamine being trapping agent. NO₂ concentrations were measured simultaneously at several sites with different traffic density from June to September 2007. Most of measurements were made in duplicate. Comparison of passive and discrete active sampling results was made. Concentrations obtained by passive samplers were found to be systematically lower than those obtained by active sampling method.

The use of passive samplers to determine levels, and exposure on children, of 1,3-butadiene and benzene in Mexico City Metropolitan area

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Volatile organic compounds (VOCs) such as benzene and 1,3-butadiene are important airborne contaminants because of their well-known impact on human health and the environment. Thus, a precise measurement at trace levels in ambient air is of outmost interest. To measure the exposure of the general population, there is a need to use samplers which can be used for long periods (weeks) as well as for shorter periods (≤ 24 h). Ideally, this should consider a sampling time relevant to exposure scenarios, and hence representative for possible health effects (i.e. short exposure time for acute effects and longer exposure times for chronic/cumulative effects). Indoor air VOC concentrations can be monitored by either stationary or personal monitors. Herein we report the use of different sampling strategies to illustrate the exposure scenarios to 1,3-butadiene and benzene of a group of elementary school students and their parents living in three different sites (T0, T1, T2) of Mexico City Metropolitan Area (MCMA) during the MILAGRO 2006 campaign.

Two types diffusive samplers SKC-Ultra (SKC Inc.) and Perkin Elmer tubes filled with Carbo-pack X were used. The sampling sites were T0 - within MCMA situated Iztapalapa, T1 - at the Universidad Tecnológica de Tecamac in the state of Mexico and T2 - in Rancho La Bisnaga y San Pedro, in the State of Hidalgo. Stationary sampling was carried out for 7 days and 24 h inside and just outside the place of living. The stationary sampler was placed at a height resembling the breathing zone, in the living room. Moreover, a personal sampler was attached to the collar of a child as close to the breathing zone as possible for 24 h. The analysis and detection were performed using an automatic thermal desorber (ATD) connected to a gas chromatograph with a mass spectrometry detector (GC/MS).

Both 7 day and 24 h outdoor sampling reveals similar although somewhat higher levels of both targets at the T0 site compared to the other two sites. Depending on sampling site the concentrations ranged typically from 0.3 - 4 $\mu\text{g}/\text{m}^3$ and 2 - 10 $\mu\text{g}/\text{m}^3$ for 1,3-butadiene and benzene, respectively. These levels are higher than those observed at urban sites in Sweden. A comparison between in and outdoor, the levels showed a rather uniform picture for the compounds although at some indoor places the 1,3-butadiene levels were high. The reason may be cigarette smoke.

In general the personal samplers result reflects those obtained by corresponding stationary in- or outdoor sampling results.

Atmospheric deposition of metals around some industrial plants in Norway studied by moss analysis

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In 2000 the Norwegian State Pollution Control Authority decided to carry out a study of atmospheric deposition of inorganic pollutants around 15 industrial plants in Norway. The industries in question were five aluminium smelters, one zinc smelter, six ferroalloy plants, two cement factories, and one carbide factory. The method used was sampling and analysis of naturally growing moss (*Hylocomium splendens*) at distances of 1-10 km from each plant. Mosses absorb effectively particles and ions from the atmosphere and provide relative deposition patterns of the associated pollutants. Typically 10-15 sampling sites were selected at each site considering factors such as topography and prevailing wind directions. The concentrations of 32 elements in the moss were determined by ICP-MS.

Among the trace elements studied gallium was the most typical “marker” of the Al industries. Another element observed in small but still elevated amounts at all sites was bismuth. Relatively high levels of vanadium and nickel were evident at three of the sites, most likely associated with the use of heavy fuel oil. Other elements observed at elevated levels at several sites were beryllium, chromium, arsenic, molybdenum, antimony, and tungsten. High deposition of zinc, cadmium, and mercury were observed around the Odda zinc smelter. Still the highest general metal deposition levels were observed at the town Mo i Rana where the main industries are a ferroalloy smelter and a factory recovering metals from scrap. Huge deposition of chromium was particularly evident, and metals such as beryllium, vanadium, cobalt, nickel, arsenic, zirconium, tungsten, lead, and bismuth were also present at appreciable levels. A dense sampling network and use of factor analysis facilitated to define the main polluting source in each case. Emissions from the cement industries were relatively modest.

The survey was repeated at reduced scale in 2005 at some of the most polluted sites. In several cases only small or no improvement was evident since 2000. At Mo i Rana the chromium had been replaced by a similar level of manganese deposition, following a change in production from ferrochrome to ferromanganese. Apparently there is still considerable work to be done at some industrial sites in Norway to reduce metal emissions to acceptable levels.

The use of polyurethane foam passive samplers for monitoring of indoor and outdoor air levels of persistent organic pollutants

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Exposure to persistent organic pollutants (POPs) such as PAHs, PCBs, brominated flame retardants (PBDEs), and organochlorine pesticides is regarded as an important environmental risk factor for humans. The main route of exposure is via the diet, but exposure to outdoor and residential indoor air is also important. Air concentrations of POPs are usually measured with an active sampling technique. However, they are expensive, need a source of electricity and are noisy. Thus, in some situations like in private homes and for routine monitoring, passive samplers may be the only option since they are cheap, easy to handle, small and light. In this study, the applicability of a passive air sampling methodology for PAHs and other POPs was studied. In- and outdoor air was measured at three regions of the Mexico City area during the MILAGRO campaign. The results were compared to an urban site in Sweden and United Kingdom, respectively.

Polyurethane foam (PUF) disks were used as passive air samplers. PUFs were placed in specially designed shelters for out- and indoor sampling, respectively. The sampling sites were three locations in the Mexico City area; T0 – within the metropolitan area, T1 – in the State of Mexico City and T2 – in the State of Hidalgo, Göteborg, Sweden and Lancaster, UK. PUFs were deployed simultaneously as stationary samplers inside and outside people's homes for approximately 6 weeks during March to May 2006. The samplers were solvent extracted, cleaned and analysed with HPLC connected to a fluorescence detector (PAHs) and GC/MS in SIM mode (other POPs).

In this study using PUFs we show that all compounds in the gaseous phase were collected in the sampling media in a reproducible way. Moreover, the results show that all compound groups were present in both in- and outdoor environments in all sampling sites. The concentrations found in this study were comparable to published results at urban sites using conventional active air samplers.

PAHs were most abundant of the studied compounds and phenanthrene was the main contributor to ΣPAH_{13} . Highest outdoor and indoor ΣPAH_{13} levels, respectively, were found in Mexico City ($\sim 50\text{-}90\text{ ng m}^{-3}$) and in Sweden ($\sim 70\text{ ng m}^{-3}$). PCBs were highest indoor in Sweden and UK (~ 900 respectively $\sim 850\text{ pg m}^{-3}$) and PBDEs were highest in Mexico ($\sim 100\text{ pg m}^{-3}$). Interesting, the indoor POP levels in Mexico were in general similar or somewhat lower compared to outdoor levels, but contrary, in Sweden all POPs were significantly higher indoors than outdoors.

The PUFs can yield acceptable estimates of air concentrations, and semi-quantitative assessments of the levels and patterns, which are indicative of likely sources of POPs in in- and outdoor air.

A simplified sampling design for studying chemical variability of Bromeliad leaves

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Epiphytic bromeliads are widely employed as biomonitors of atmospheric pollution, mainly species from gender *Tillandsia*. However, there is a lack of information on the applicability of other species from Brazilian tropical forests, in which the biodiversity of epiphytic bromeliads is quite high. Moreover, for studies of baseline chemical element composition of bromeliads, it is recommended to use native species occurring in well-preserved areas from conservation units.

Considering the possibility of using native species for biomonitoring, diverse studies were carried out in São Paulo State, Brazil, for finding suitable bioaccumulators. In the Atlantic Forest, one of the principal vegetational types in the State, *Canistropsis billbergioides* and *Vriesea carinata* have demonstrated accumulation of some chemical elements in leaves. Before employing as biomonitors, it became necessary to evaluate their leaf chemical variability.

In this work, a novel methodology was utilized for sampling small fragments from leaf surface. Circular fragments (diameter = 6 mm) were taken using a sampler made in Teflon. The bromeliad species evaluated have a rosette design of leaves thereby allowing to control the sampling of fragments from each position with relation to the plant and to the leaf. Six fragments were collected from bottom-, middle- and top-position of plants and leaves, resulting in nine composite samples from each rosette analyzed (total rosettes analyzed = 4). The fragments fit perfectly in the polyethylene vials, that is, no sample preparation was necessary avoiding contamination with metallic elements from milling procedure. Samples were lyophilized, and together with certified reference materials, analyzed by instrumental neutron activation analysis (INAA).

All chemical elements normally determined in leaves by INAA were also quantified in the fragments analyzed in this study. For *Canistropsis billbergioides*, a pattern of distribution of chemical elements in leaves was recognized, in which the middle-leaf fragments showed higher mass fractions of K and Rb than the top- and bottom- ones. For Zn in both species, the pattern was the opposite, in which mass fractions were lower for middle-leaf fragments, pointing out the different mechanisms of use of chemical elements depending on their functionality. Higher variability was detected in the bottom-leaf. Mainly in this part (leaves in rosette forming a tank), trichomes are present and they are responsible for the uptake of chemical elements and water from the atmosphere. The principal differences were detected for the fragments collected in the three positions of leaf despite some differences detected for bottom-, middle- and top positions

Short course 1

Sampling and analysis of welding aerosols

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This short course provides information on air contaminants related to different welding processes, parameters and materials; standardization of sampling and analysis methods for use in measuring exposure to welding fume and gases; and workplace and laboratory evaluations of a minisampler for sampling behind the welder's face shield.

Welding is the generic name given to the fabrication process for joining different materials using heat and sometimes pressure. Many different welding processes exist for joining a wide range of materials, including metals and polymers. The presentation will concentrate on arc welding, which is widely used for joining metals, and consists of four main processes: manual metal arc (MMA) welding, metal inert gas and metal active gas (MIG/MAG) welding, flux-cored arc (FCA) welding and tungsten inert gas (TIG) welding. Depending upon the welding process and parameters, consumables and materials, emissions of different composition will occur and at different emission rates. For example, FCA and MMA welding can emit fume at high rates whilst TIG welding emits hardly any fume at all. TIG and MIG welding can emit substantial amounts of ozone whereas ozone emission from MMA welding is very low. Some processes emit chromium in the hexavalent state whilst others do not. Important differences of these types, between fume and gas emissions when welding with different processes, parameters and materials will be presented and discussed.

International and European standardization in the field of health and safety in welding is carried out by ISO/TC 44/SC 9 and CEN/TC 121/SC 9. The most relevant standards are: EN ISO 10882 Parts 1 and 2 on sampling of airborne particles and gases in the operator's breathing zone; EN ISO 15011 Parts 1 to 6 on determination of emission rates of fume and gases and fume data sheets; and EN ISO 15012 Parts 1, 2 and 3 on requirements, testing and marking of equipment for air filtration. An overview of the various standards will be presented, mentioning the arrangements for sampling behind the welder's face shield used in different countries and the *pros* and *cons* of using fume analysis data to estimate exposure.

A minisampler has been developed using a Swinnex filter holder for 13 mm filters with a 10 mm nozzle. The minisampler is mounted on a modified headset to keep it close to the welder's nose and mouth, irrespective of the position of the welder's face shield (up, down or off). The sampling efficiency of the minisampler has been investigated at five manufacturing workshops and it has been used for personal sampling at three of these. The sampling efficiency of the minisampler versus the IOM sampler and the 25 mm filter holder (open-face) and the experience of using it for personal sampling will be presented, as well as calibration of portable XRF instruments for the direct analysis of manganese and iron on filters. The workplace evaluation shows that its bias relative to the IOM sampler is approximately twice its bias relative to the 25 mm filter holder.

The sampling efficiency of the minisampler has been evaluated in a set of laboratory tests in which a simplified mannequin (CalTool) with a human-shaped head wearing a modern welder's visor was exposed to welding fumes generated directly in front of the mannequin. The mannequin inhaled through the mouth and one minisampler was mounted on each side of the head. In addition, IOM samplers were mounted on both the left and right side of the neck and further below on the chest. The minisampler was found to have a strong linear relationship with the mouth (slope 1.02, $R^2 = 0.9$) and there was no difference between the left and right position. For the IOM sampler the relationship with the mouth was more variable (slope ~ 0.4 , $R^2 = 0.1$) and there was no statistically significant difference between the left-right position although the data was very variable.

Short course 2

How to select a method for isocyanate monitoring in the workplace

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There are several methods available for the measurement of isocyanates with different possibilities and drawbacks. For the occupational hygienist the aim of the measurement and possibilities of different methods to fulfil the aim is crucial and the analytical laboratory procedures are of minor interest. For the choice of appropriate method to assess the exposure it is important to identify all possible routes and work tasks where there is a potential for exposure, such as infrequent or intermittent handling of isocyanates, cleaning of equipment, maintenance, heating, filling isocyanate containers, etc. Changes to the production process (e.g. use of different formulations, modification to the process line, etc.) may require reconsideration of the used methods for new measurements.

Advanced sampling and analysis can be performed using e.g. midjet impingers, impactor samplers and other special samplers. The aerosol can be characterized with regards to particle size distribution, concentration and chemical composition. When the detailed nature of the exposure is known, the sampling and analysis can be simplified. Time resolved sampling with direct reading monitoring can be performed for some isocyanates. The individual exposure may be revealed by biomarkers. For some isocyanates, there are BEIL defined or suggested. The physical state of the isocyanate(s) present in the atmosphere affects the appropriate sampling technique. Spray paint aerosols and condensation aerosols are very different. Polyurethanes start to thermally degrade at temperatures above 150 °C to 200 °C, possibly resulting in the emission of monomeric diisocyanates, monoisocyanates, aminoisocyanates, and amines both in gas and particle phases.

If compounds that can react with isocyanates are present in air, they can compete with the derivatization reagent, causing inaccurate analyses. Solvent-free sampling is more affected by competing reactions than wet sampling. Reacting aerosols (e.g. spray painting) are problematic due to the creation of many new isocyanate containing compounds. These are difficult to measure as reference compounds in most cases are missing.

Short course 3

Field experience with aerosol samplers in workplaces

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The history of health-related aerosol standards for workplace exposures owes much to the growth of knowledge and development of sampling instruments, going back to the early 1900s and continuing to the present day. Over the years, there have been many shifts in sampling philosophy and criteria, accompanied by advances in sampling devices and strategies, leading in turn to adjustments to standards and exposure limits. Occupational epidemiology has been a major stimulant. Many of the diseases associated with aerosol exposures at work have long latency periods, where clinically diagnosable outcomes may appear only long after the relevant exposure history began. But the changes in exposure assessment methodology over time have complicated the historical occupational exposure data bases required to gain a full understanding of the aetiology of such diseases. Field experiments with the various aerosol sampling instruments that have been proposed have provided important steps along the road to implementation of continuously-improving methodologies and equipment. Of particular interest are the field studies aimed at providing exposure histories described in terms of single, most-relevant indices. Important ingredients towards achieving this goal have been the side-by-side studies that have been carried out in the field in order to make direct comparisons between instruments and sampling approaches under real-world conditions.

The sampler testing protocol EN 13205 developed by the Comité Européen de Normalisation (CEN) entitled "*Workplace atmospheres – assessment of performance of instruments for measurement of airborne particle concentrations*" (CEN, 2002), includes guidance not only on the laboratory testing of aerosol samplers but also field studies. In such field studies, the protocol requires the identification of an existing aerosol sampler that has been shown to accurately and consistently collect the fraction of interest, and then its operation in the field alongside candidate other samplers for the same fraction. Here, therefore, the chosen sampler is a reference instrument, against which all the others are to be compared. EN13205 specifies that such comparisons should be carried out for as wide a range of conditions as possible pertaining to the field site(s) in question.

In this tutorial, examples are given of some of the key field studies that were subsequently influential in the longer run of occupational exposure assessment, occupational epidemiology and standards setting, marking important milestones in the various transitions that have taken place as perspectives and priorities have shifted.

Short course 4

How to deal with dampness/moisture problems from a practitioners' point

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Short course 5

An introduction to Proton-Transfer-Reaction Mass Spectrometry (PTR-MS)

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Short course 6

Field experience with aerosol samplers in the ambient atmosphere

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The development of sampling criteria, standards and sampling methods for aerosols in the ambient atmosphere has followed a somewhat different path than for workplaces. Unlike the case of occupational aerosol measurement, there have not been the swings between the indices of particle number count and mass concentrations. With the exception of asbestos fibres, aerosol levels in the ambient atmosphere have nearly always been defined in terms of the mass concentration. Even where black smoke was the chosen index, it was expressed – by calibration of the optical method underpinning its determination – in terms of the mass concentration of soot. Furthermore, most sampling for ambient aerosol has involved instruments placed at fixed points. As far as sampling criteria are concerned, whereas the international focus for occupational environments has converged for the most part on the CEN/ISO/ACGIH conventions, the emphasis for ambient atmospheric aerosol has moved increasingly towards the PM₁₀ – and latterly PM_{2.5} – philosophy first introduced by the United States Environmental Protection Agency (EPA).

EPA has promulgated procedures – contained in the Federal Reference Method (FRM) – for testing samplers, specifically most recently for samplers for the PM₁₀ and PM_{2.5} fractions. The formal documentation required not only laboratory tests but also the identification of one or more samplers as reference samplers, and their application in field studies alongside one or more of the candidate samplers for the same fraction. Europe followed along similar lines when the Comité Européen Normalisation (CEN) published its protocol EN 12341 that described standardized procedures for testing samplers for the PM₁₀ fraction that, too, placed considerable emphasis on field studies. So, on both sides of the Atlantic, field studies of prospective new samplers were therefore formally built into the standards infrastructure. Many other nations have since followed. That said, however, the need for field studies to validate emerging new aerosol samplers was acknowledged much earlier. A vast literature has grown over many years, describing many applications of samplers of diverse types in the ambient atmosphere, many of them of local interest only, for example providing data in relation to air pollution levels in specific cities or regions, without adding significantly to aerosol sampling science. In this tutorial, therefore, attention is focused on those field studies that have provided bridges between different approaches or otherwise elucidated the nature of aerosol sampling problems and solutions.

Short course 7

On-site measurement - a tool for direct assessment of exposure

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Traditional assessment of occupational exposure to chemical compounds in the workplace is a two-step procedure. The procedure typically first involves static or personal sampling of aerosols on a membrane filter using a pump and/or gases or vapors on an adsorbent or chemisorbent using a pump or by diffusion. The second step is a laboratory analysis to identify and determine the amount of the chemical compounds in the samples followed by calculation of the concentration of the compounds in the workplace air. These techniques are well established and frequently applied. However, they all have a drawback in that, since the samples have to be analysed in a laboratory, the results will usually be obtained days or weeks after the sampling took place.

With an on-site measurement procedure it is possible to get the results almost immediately after the sampling, which opens for new assessment strategies. Today there a number of direct reading instruments are available for a variety of chemical compounds as well as aerosols. Moreover, portable and battery-operated electronic micro-balances and instruments for metal analysis based on X-ray fluorescence spectrometry are available. Together, these instruments will make on-site measurements of exposure to various chemicals and metals possible, which opens the way for new approaches for assessment of occupational exposure.

In this course various on-site measurement procedures will be described and various monitoring strategies will be exemplified with description of practical applications. Short-term sampling, which is possible for aerosols, using high-flow pumps, allows monitoring the exposure during individual work tasks of short duration. The exposure variation during a work shift can also be monitored by short term sampling. Wipe sampling is another sampling procedure that makes it possible to assess the spatial distribution and deposition of aerosols. Screening measurements and emission measurements are other examples of monitoring that are facilitated using on-site determinations. Control of various preventive or precaution measures can rapidly be performed using on-site measurements and is an effective tool in the assessment of workplace improvements. On-site determinations in combination with video technique can also form an effective and pedagogic tool showing workers how to perform specific tasks and demonstrating the effectiveness of different measures intended to improve their work environment. Other examples are the assessment of skin exposure using aerosol deposition on pads and screening of contamination using bulk samples.

Poster 1

Database of international limit values for workplace air

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Workplace limit values constitute an important instrument for the protection of employees' health and safety against dangers posed by hazardous substances. Almost all industrial countries impose workplace limit values for hazardous substances which take the national conditions into account. The lists of limit values vary in their scope, in some cases considerably, and it is quite common for a given substance to be missing from a national list of limit values. In such cases, a foreign atmospheric limit value for example may be used in Germany for performance of the risk assessment and for analysis of the working area.

In many cases, the lists are not available in English, but only in the national language, which can make the search for an atmospheric limit value in a list of national limit values particularly difficult. Together with 12 OSH institutes from Europe, the USA, Canada and Japan, the BGIA launched the "GESTIS International limit values for chemical agents" online database (URL: www.dguv.de/bgia/gestis-limit-values) in mid-2006. The database is to be extended progressively in the coming years.

The database is updated regularly and is up to date as at the end of 2007. The database is in English, and contains limit values for over 1,250 substances. Since substance names are not always unambiguous, for example because their definitions or names do not always correspond one-to-one in the lists of limit values, the CAS number is recommended as the primary search criterion for substances.

The purpose of the database is to provide users with a rapid overview of limit values for the assessment of workplaces. It contains only the eight-hour limit value and short-time values of the substances concerned; information on carcinogenic effects, for instance, is not included.

Poster 2

Trichloroamines in German indoor swimming baths - results of a nationwide measurement programme

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Trichloramine (TCA) occurs as a by-product when chlorine is used for the disinfection of swimming pools and reacts with human urea. TCA is suspected of causing disorders of the respiratory tract. TCA does not dissolve easily in water and is therefore rapidly outgassed in swimming pools, giving rise to the familiar swimming-bath odour.

Between 2005 and 2007, the BGIA first developed a measurement method based upon a method which had already been described in France², and then conducted a representative measurement programme in various types of swimming bath throughout Germany.

The measurement method is based upon the hydrolysis of trichloramine and the reaction with As_2O_3 on a quartz-fibre filter subjected to alkali impregnation with sodium carbonate/ As_2O_3 , and ion-chromatographic analysis of the resulting chloride. Interfering substances present in the atmosphere, such as free chlorine, are collected by an upstream silica gel cartridge.

Altogether, 703 measurements were performed in 92 swimming baths; all swimming-bath types, such as normal indoor baths, adventure baths, school swimming baths and therapeutic baths were considered, as was the impact upon supervisory personnel and in the engineering control area. The results show that the outgassing of TCA is influenced by a range of factors, such as the number of people using the pool, the water temperature, and the intensity of water splash. Concentrations as high as 1 mg/m^3 were measured sporadically; the 90th percentile was around 0.4 mg/m^3 , and over 50% of results were below 0.15 mg/m^3 .

Higher exposures were frequently measured in newer or renovated swimming baths. Such baths generally have features such as slides or whirlpool baths which cause more rapid outgassing of the TCA. In addition, the ventilation systems in these baths recirculate a high proportion of the air for energy-saving reasons, whereas the ventilation systems in older swimming baths employ a high outside air component, and TCA is not therefore able to build up in the indoor areas.

² Metropol Fiche 007, Trichlorure d'Azote et autres composés chlorés, 2002

Poster 3

Dust exposure in indoor climbing halls

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Due to the large number of epidemiological studies which consistently showed a relation between ambient aerosol concentrations and adverse health effects research on particle toxicology has shifted from industrial occupations to ambient particulate matter. However, as people in developed countries spent most of their time indoors, the total exposure is strongly dominated by indoor sources. Indoor climbing is a good example of a leisure activity that is associated with exposure to high particle concentrations. In the last two decades, indoor climbing became a popular leisure activity in many countries. For example, in 2007 there were approximately 230 indoor climbing halls in Germany with more than 250,000 users. Although there is no reliable information available, the worldwide number of people climbing regularly indoors is most likely above two million.

We have measured the aerosol mass concentrations (PM_{10} , $PM_{2.5}$, PM_1) in ten different indoor climbing halls in Germany by means of an optical particle counter. In addition, we also determined the size distribution from 3.2 nm to 10 μm and collected particles for scanning electron microscopy in one indoor climbing hall.

Aerosol mass concentrations strongly vary with the number of climbers present. PM_{10} increases from values of 300 – 500 $\mu\text{g}/\text{m}^3$ if few users are present to values between 1000 – 2000 $\mu\text{g}/\text{m}^3$ for periods of high activity. $PM_{2.5}$ and PM_1 show the same behaviour, i.e., the ratios of $PM_{2.5}/PM_{10}$ (mean value: 0.139) and PM_1/PM_{10} (mean value: 0.035) are rather constant. The highest average mass concentrations were observed for bouldering with PM_{10} mean values up to 4000 $\mu\text{g}/\text{m}^3$. In large commercial climbing halls, mean values of PM_{10} for the complete opening hours (up to 16 hours a day) are on the order of 1000 – 1200 $\mu\text{g}/\text{m}^3$. For some days, we also measured the inhalable fraction, and a mean value for the ratio of inhalable dust to PM_{10} of 2.3 was found. Scanning electron microscopy and energy-dispersive X-ray microanalysis revealed that practically all particles are hydrated magnesium carbonate hydroxide (magnesia alba, $\text{Mg}_5(\text{CO}_3)_4(\text{OH})_2 \cdot 4-5\text{H}_2\text{O}$), which is used by climbers for drying the hands. For comparison, we have also measured particle mass concentrations for other indoor sports and found much lower values mostly $< 100 \mu\text{g}/\text{m}^3$.

The dust concentrations in indoor climbing halls are much higher than those generally encountered in schools. According to Fromme et al. (2007), median PM_{10} concentrations are usually below 100 $\mu\text{g}/\text{m}^3$ in individual classrooms. PM_{10} concentrations on the order of 1000 – 4000 $\mu\text{g}/\text{m}^3$ (mean values for periods of high activity) are found in many industrial occupations. The high dust concentrations in indoor climbing halls observed in the present study are not acceptable for leisure activities. It should be mentioned here that children and even babies are frequently exposed to these high dust levels. Therefore, strong efforts to reach a substantial reduction of the aerosol concentrations are highly desirable.

H. Fromme, D. Twardella, S. Dietrich, D. Heitmann, R. Schierl, B. Liebl, and H. Rden (2007). *Atmos. Environ.* **41**, 854-866.

Poster 4

Chemical characterization of water-soluble ionic species in PM₁₀ in the ambient air over Northern Belgium

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Particulate matter (PM) has been given much attention in recent decades due to its potential health impact and important role in global climate changes. Typically particle mass is dominated by sulphate, ammonium, nitrate, organics, soil/road dust and elemental carbon. In fact, ionic components are the main part of atmospheric aerosols, which can comprise up to 60-70% of the total particulate mass. In addition, the analysis of these compounds can yield sound information about the possible contribution of sea-spray (Na⁺, Cl⁻, Mg²⁺) and of secondary aerosols (SO₄²⁻, NO₃⁻, NH₄⁺) to PM. The concentrations of acid-forming constituents as sulfates and nitrates and together with ammonium have been recognized as some of the major pollutants with harmful impacts on human health, natural environment, radiation balance, visibility, ecological systems, and plants. Particulate NH₄⁺ found in the atmosphere originates from NH₃ by the neutralization between ammonia and acidic species. Soluble K⁺ is widely accepted as fingerprint of biomass burning. Ca²⁺, regarded as a crustal element, was the species most enhanced in sand storm events. Therefore, chemical characterization is required to differentiate between locations or to indicate the influences of local sources.

As a part of the Chemchar PM₁₀ project of the Flemish Environmental Agency (VMM), atmospheric PM₁₀ and its major ionic components (MICs) were monitored in a one-year-long campaign, at six locations of different anthropogenic influence (industrial, urban, suburban, and rural) in Northern Belgium (Flanders). For each sampling site, the ratio of MIC to PM₁₀ was on an average of 44%, with values varied from 41% to 50%. The higher average percentage around 17%, 11% and 5% was for NO₃⁻, SO₄²⁻ and NH₄⁺, respectively (in the case of Cl⁻ and Na⁺ it was around 4%). It was also found that for all anions nitrate was the highest abundant component in PM₁₀ followed by sulfate, while the concentration of chloride were much lower. The average levels of NO₃⁻ and SO₄²⁻ were between 5.55-8.00 $\mu\text{g m}^{-3}$ and 3.26-4.33 $\mu\text{g m}^{-3}$, respectively. In the case of Cl⁻, concentrations ranged from 0.74 to 1.46 $\mu\text{g m}^{-3}$. The primary cation of PM₁₀ was NH₄⁺, of which mean values between 1.87-2.47 $\mu\text{g m}^{-3}$. Other cations like Na⁺ and K⁺ were found to be two times and four times less abundant, respectively, in comparison to NH₄⁺. Concentrations of Ca²⁺ and especially Mg²⁺ were found to be much lower.

The concentrations of individual ions were for each location in the same order: NO₃⁻>SO₄²⁻>NH₄⁺>Cl⁻>Na⁺>K⁺>Ca²⁺>Mg²⁺, respectively. However, as it was expected, the highest concentration of NO₃⁻, SO₄²⁻ and NH₄⁺ were detected in industry and urban sites. Also high concentrations of NH₄⁺ were found in rural sites, what can be connected with animal farming and fertilizers. The higher concentrations of Cl⁻ were determined at locations close to the North Sea. The daily variations of MICs in PM₁₀ showed the relative importance of weather conditions such as wind direction, temperature and precipitation on the formation of aerosols.

Hierarchical cluster analysis (HCA) was made in order to find the association of groups of compounds in PM₁₀. Possible pollutant sources were addressed with the use of principal component analysis (PCA). The acidity of PM₁₀ and the amount of sea-salt chloride lost during atmospheric transportation helped to understand some of the atmospheric processes that were active at the sampling sites.

Poster 5

Aerosol and gaseous pollutant investigations in the field of cultural heritage research

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Airborne pollutants in combination with the microclimate and management of the collections form the main thread in Cultural Heritage institutions. Pollutant concentrations as well as their sources have to be investigated together with possible ways of deterioration of the objects of art in order to assess the exposure conditions.

Aerosol samples and gaseous pollutants have been collected in several European museums in order to achieve an integrated view of the environment and the possible threatening factors for the deterioration of works of art. Samples were taken indoors, inside showcases and outdoors of the museums. Particulate pollutants were taken with the use of a Berner impactor on different substrates (Ag and Si) for size segregated single particles and a Plexiglass[®] filterholder unit on Nuclepore[®] membranes for bulk particles.

The chemical composition and size characterization of atmospheric particulate pollutants was carried out by using computer-controlled electron probe microanalysis (CC-EPMA) at the single particle level and energy-dispersive X-ray fluorescence (EDXRF) for bulk analysis.

Gaseous pollutants such as NO₂, SO₂, O₃, HCOOH and CH₃COOH were sampled by means of Radiello[®] diffusion tubes. The small size diffusive samplers allowed measuring the concentrations of gaseous pollutants, even in the showcases. The analyses were performed by means of ion chromatography (IC) and UV/VIS spectrophotometry.

EDXRF results showed an accumulation of particulate pollutants in some of the monuments due to the visitors and activities taking place inside the museums.

From the obtained results for the gaseous pollutants it can be clearly seen that outdoor generated pollutants as NO₂, SO₂ and O₃ had lower concentrations in the museums than in the outdoor air. However, acetic and formic acid had higher concentrations in the museum showcases and galleries compared to outdoors as they are mainly generated from indoor sources.

Poster 6

Investigation into the levels of NO₂, SO₂ and O₃ using passive samplers in the ambient air of Dar es Salaam, Tanzania

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While many investigations on atmospheric pollution have been conducted in Europe, North America, South America and various parts of Asia, only a handful of such studies have been reported for Africa, especially Sub-Saharan Africa. Atmospheric pollution which is associated with atmospheric pollutants viz particulate matter and gaseous pollutants, cause a wide spectrum of effects including atmospheric corrosion of metal and cementitious materials. It is now an increasingly important environmental problem due to the increase of industrial activities, traffic, biomass burning, and the ever increasing demand for power, mostly supplied by coal-driven power plants introducing air pollutants into the atmosphere. Atmospheric corrosion of local building materials, galvanized corrugated iron sheets widely used as roofing materials and cement mortar blocks, along the coast of Dar es Salaam and Coast regions, is a major problem.

As part of solving this problem, the ambient air quality to which the local building materials are exposed to, was determined by measuring concentration levels of NO₂, SO₂ and O₃ gaseous pollutants at exposure sites, S1, S2 and S3 (aligned at intervals 0 km, 15 km and 40 km from the coastline to observe the influence of marine atmosphere). Gaseous pollutants were sampled using passive samplers with a radial symmetry and sampling campaigns were conducted once per climatic season (two dry and two wet seasons per year), for four consecutive years, 2004 to 2007. The concentrations of NO₂ and SO₂ were determined by ion chromatography (IC) whereas for O₃, UV/Vis spectrophotometry was used, with meteorological parameters at all exposure sites being provided by the Tanzania Meteorological Agency (TMA). Possible sources for the concentration variations were identified for S1, S2 and S3. Sites S1 and S2 had similar results as expected since these sites' environmental conditions are analogous, whereas S3 represents a rural environment. During all seasons higher NO₂ and SO₂ concentrations levels were observed at S2 (40.2 and 6.4 µg m⁻³, respectively) in comparison with S1 (21.8 and 3.4 µg m⁻³, respectively) and S3 (8.2 and 1.9 µg m⁻³, respectively), suggesting increased levels of potentially corrosive gases due to its combination with water vapour. At S3 higher ozone concentration values (31.8 µg m⁻³) were observed. This paper reports the concentrations of the gaseous pollutants on the Tanzanian coast in relation to the meteorological conditions as well as the air mass movements, as shown by backward trajectories. The obtained results were compared to studies conducted at the European/Belgian coasts as reported in open literature and as part of a study on the atmospheric nitrogen input at the North Sea performed by the ECO group, University of Antwerp, Belgium.

Poster 7

Development of measuring methods for biological monitoring of occupational exposure

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In recent years bio-monitoring of hazardous substances in human urine has become an integral part of the risk assessment process for a number of industrial organic solvents.

2,5-Hexandione (2,5-HD) is a neurotoxic metabolite of *n*-hexane (and methyl butyl ketone) excreted with urine. Because of the good correlation between exposure to *n*-hexane and urinary excretion of 2,5-HD, this substance can be used for biological monitoring of occupational exposure. For the determination of 2,5-HD in urine without using organic solvents, a method based on headspace solid-phase microextraction (HS-SPME) and gas chromatography-mass spectrometry (GC-MS) was developed. After acid hydrolysis (4% HCl, 98 °C, 2 hours), the urine sample was neutralized with sodium citrate. Sodium sulphate was added and the sample was stirred 2 hours in a sealed glass vial at temperature of 28.0 °C. For HS-SPME sampling, polyacrylate coated fiber (85 µm) and extraction time of 10 min were applied. Analytes were desorbed at temperature of 260 °C for 1 min. Limit of detection (S/N of 3 : 1) was 0.01 mg/L. The inter-day reproducibility of the determination at concentration level of 5 mg/L was 2.8%. Linearity was evaluated in the range of 1-25 mg . Using standard addition method with internal standard of methyl levulinate, the relative standard uncertainty of the determination at 5 mg/L level was 3%.

2-Ethoxy- and 2-butoxyethanol, which are mainly metabolised to the corresponding alkoxyacetic acid. Many analytical methods have been applied to the quantification of ethoxy- and butoxyacetic acids including GC, GC-MS, HPLC and HPLC-MS. For most of these methods complex sample preparation is usually needed, like extraction and or derivatization. It will be presented a selective and reliable, two-dimensional HPLC-MS methods for the determination of these free acid metabolites. Because of the two dimensional separation approach, direct injection of acidified and centrifuged urine samples can be applied. For both methods the separation in the first dimension was obtained using a Zorbax SB-Aq column with a simple step gradient, while a short SAX column in isocratic mode was used in the 2nd dimension. Ethoxy- and butoxyacetic acids were detected and quantified with an ion trap MS using negative APCI ionisation and selective ion monitoring of the M-HI- ions of the analytes and the deuterated internal standards. After development the methods were extensively tested for linearity, selectivity and recovery with spiked urine samples. The MS response was linear in the investigated 5-60 mg/L range. Recoveries from human urine were greater than 98% with RSD less than 5%.

Poster 8

Ecological and biochemical principles of an elements composition estimation of an agriculture landscape

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The main ecological task today is not a rescue of a separate biosphere parts but a preservation of the nature as a single whole with all of its components, among which the central one should be top-soil cover - the correlation center in biosphere where proceed the very manifold processes of matter and energy exchange between lithosphere, hydrosphere and all of the living beings, including human beings. Top-soil cover is a container of environmental pollutants so as wherever on land pollutants are thrown out, they get to soil cover after all.

Living beings and abiotic environment of their habitat on the specific territory are linked together by biogeochemical circulation of chemical elements.

The basic principles of ecobiogeochemical estimation of territories are expressed in the following:

1. In connection with biogeochemical heterogeneity of an inhabitancy of living beings (owing to natural heterogeneity and caused by techno-genesis) it is important to define the element status of probably wider spectrum of chemical elements (essential and toxic) in concrete territory.
2. There should be an ecological system approach including producers (plants), consumers (animals) and regenerators (bacteria, fungi, etc.), allowing natural ecosystems to maintain their stable state for an indefinitely long time to support the stable condition, not suffering from an exhaustion of resources and disposals of waste.
3. It is necessary to pass from the description of properties of separate components (ground, air, water, plants, animals) to studying functioning ecosystem as single whole where unit of interrelations in concrete territory is the soil cover.
4. Considering regional (geographic) characteristics of a certain territory it is necessary to establish ranges of normal content of chemical elements in soil cover, plants, air, water, biosubstrata of animals. Comparisons of real element content in an appointed territory with its upper and low critical levels in specific objects allow revealing problem situations.
5. As a rapid analysis method of eco-biochemical estimation of an agriculture landscape it is worthwhile to use chemical element analysis of cattle hair, cattle being reared by natural pasturable forages, grown up on the given territory.

Poster 9

Portable nanoparticle aerosol monitor “Nano Check”

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This unique nanoparticle detector for total number concentration, mean diameter AND total active surface area (Fuchs) is based on a new patented method. The detector can be used stand-alone or combined with the well known Grimm Aerosol Spectrometer model 1.108 or 1.109 for occupational safety and health applications to measure classical inhalable, thoracic and alveolic PM-fractions, according to EN 481 standard, as well as nanoparticle exposure doThe Instrument.

The Nano-Check™ 1.300 is a very compact, portable monitor that can be used as a personal exposure monitor. In combination with any Grimm Aerosol Spectrometer, it is able to measure in real time the particle size range from a few nanometers up to 30 µm in over 30 different size channels. This new industrial hygiene tool could be used as an additional extension for all Grimm Aerosol Spectrometers to increase the range. On top of that, it can measure in real time the nanoparticle aerosol exposure in various places and situations on-site. wn to 10nm. In addition to the number-based measurements by our Aerosol Spectrometers, we can now report the total number concentration down to 10 nm, the surface area and a mean diameter. Simply attach the Nano-Check™ 1.300 to any existing Grimm Aerosol Spectrometer to determine more precise than ever the local nanoparticle exposure situation in real-time for any risk prevention. This powerful combination will help understand the change in the size distribution as well as the change of total surface area in an overall exposure scenario.

This new Nano-Check™ 1.300 sensor is based on a combination of a unipolar diffusion charger, a conductivity measurement and an aerosol electrometer. The combination of an ion attachment by diffusion from an electrical charger with the detection of the total charge is a well known technique for measuring the so called “active surface area”. The current is nearly proportional to the product of particle concentration and mean diameter. In addition a new method for conductivity measurement is implemented in the sensor. The result of the conductivity measurement combined with the diffusion charger, the current of the aerosol electrometer and a calibration factor enables this setup, to get the total number concentration in the range of ~10 nm to 500 nm and the mean diameter of the aerosol number distribution function in real time.

Poster 10

A control-based biological monitoring guidance value for PAHs and a follow-up study of exposure in UK workplaces

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A 1998 HSE survey of 25 UK workplaces with potential exposure to polyaromatic hydrocarbons (PAHs) enabled HSE to adopt a biological monitoring guidance value (BMGV) of 4 µmol 1-hydroxy pyrene/mol creatinine based on the 90th percentile of data from workplaces with good control. In 2006, as part of a HSE's disease reduction programme, several workplaces were visited/revisited to examine current levels of exposure.

Workplaces in the current study were selected based on those found to have a raised exposure in 1998. An occupational hygienist visited each site and made an assessment of the exposure controls and arranged for urine sample collection. Chimney sweeps, omitted from the original survey, were included in this study. The hygienist visited a typical site and using a trade association contacted 25 others. A further 9 sweeps were identified by telephone directory and all were contacted by post. All workers were asked to collect samples of urine pre- and post-shift for 5 consecutive days for analysis of 1-hydroxypyrene.

Fourteen out of 97 post-shift urine samples from 22 workers on 2 sites distilling coal tar had 1-hydroxypyrene levels above the BMGV and 9 of these were from maintenance workers on one site. One of these sites took part in 1998 and since then the company ownership and management has changed. In the 5 work tasks that could be compared in the two studies, the levels of 1-hydroxypyrene were now lower in all 5 tasks. Fifty eight urine samples were received from 6 workers impregnating timber with creosote and 2 out of 29 post-shift samples had levels of urinary 1-hydroxypyrene above the BMGV. Thirty five chimney sweeps provided 330 urine samples. All except 2 were below the BMGV and 298 had 1-hydroxypyrene levels below the limit of detection.

Biological monitoring is a useful aid to the assessment of occupational exposure to PAHs. A biological monitoring guidance value based on the 90th percentile of workplaces with good control is useful for targeting workplaces and tasks where exposure is higher and controls could be improved. Urine results in two studies from workers doing the same tasks but separated by 7 years show how improvements in controls can reduce exposure and reduce risk of ill-health.

Poster 11

Biological monitoring: A tool to aid the assessment of dermal exposure

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Biological monitoring (BM) is the analysis of hazardous substances or their metabolites in urine, blood or breath as an aid to assessing individual systemic exposure. In the UK, the Health and Safety Executive (HSE) has a framework for biological monitoring that suggests BM be considered for those substances that can be absorbed through the skin and give rise to systemic toxicity or where control of exposure relies on respiratory protective equipment. This study looked at recent examples of BM by the Health & Safety Laboratory (HSL) to illustrate the utility of BM to help assess dermal exposure.

MbOCA (4,4'-methylene bis(2-chloroaniline)) is an aromatic amine used for curing polyurethanes. It is a suspect human carcinogen and exposure to it needs to be well controlled. MbOCA is absorbed through the skin and in the occupational setting the major route of entry into the body is by dermal absorption. HSL has been monitoring occupational exposure to MbOCA, by analysis of MbOCA in urine samples, for over 30 years. The 90th percentile data demonstrates a gradual reduction in exposure over the years. MbOCA and this type of data was the model for a type of biological monitoring guidance value that is not health related. This type of guidance value was originally called a Biological Action Level, then a 'Benchmark' value and most recently a Biological Monitoring Guidance Value (BMGV). The guidance values is simply based on the 90th percentile of data from workplaces with good control of exposure and all that is required is that the exposure controls should be investigated for any value that exceeds the BMGV. This simple mechanism gives a feedback loop that targets investigations where they are needed and gradually reduces exposure. From a regulator's perspective it demonstrates improving control, reducing exposure and risk of ill-health. The same approach can be used within an individual workplace or for an individual worker. Urinary MbOCA analysis has proved to be a valuable tool for occupational hygienists and health professionals to identify and quantify a mainly dermal exposure hazard.

A second example comes from a HSE survey of occupational exposure to polyaromatic hydrocarbons (PAHs) in a wide range of workplaces. PAHs are complex mixtures of variable composition. Many individual PAHs are carcinogenic and there is concern about occupational exposure. The HSE survey looked at inhalation exposure, dermal exposure and methods of control and used biological monitoring based on urinary 1-hydroxy pyrene to assess systemic exposure.

A graph of all the results of biological monitoring and air monitoring of benzo(a) pyrene (BaP) shows a poor correlation. There is significant inhalation exposure to BaP without any corresponding increase in urinary 1-hydroxypyrene and also significant urinary 1-hydroxypyrene with little inhalation exposure to BaP. The former may be due to workers wearing RPE and the latter to dermal exposure. If the data is filtered to exclude those sites where the occupational hygienist saw the workers using RPE or where he thought there was scope for dermal absorption of PAHs, the correlation improves dramatically. This demonstrates the utility of biological monitoring to assess dermal exposure as well as the effectiveness of RPE. HSE proposed a BMGV of 4 µmol 1-hydroxy pyrene /mol creatinine based on the 90th percentile of data in workplaces deemed to have good control in this study.

Biological monitoring is a useful tool for assessing dermal exposure. It has a particular role for those substances with 'skin' notations where the dermal route can contribute significantly to systemic toxicity. The 90th percentile approach is a non health-based approach to easily producing biological monitoring guidance values that can aid exposure assessment and the adequacy of controls. It is an approach that allows regulators, companies and individual workers to target improvements in control and demonstrate reductions in exposure.

Poster 12

The role of interior textiles in environmental tobacco smoke exposure

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Environmental tobacco smoke (ETS) exposure is one of the major problems of indoor air quality (IAQ). According to the classification of the International Agency for Research on Cancer (IARC), ETS with respect to its potential carcinogenic risk falls within group I. Involuntary smokers (IS) who share premises with smokers form the group at the higher risk. The users of premises where tobacco is smoked are subjected to direct ETS inhalation exposure as well as to inhalation of volatile substances adsorbed from ETS and then remitted from interior textiles and solid particulates with physically and chemically adsorbed substances.

Interior textile materials are characterized by an extensive surface area (especially textile floor coverings - TFC) and high sorption therefore, they play an essential role in shaping IAQ and exposure of IS. Textile materials can remit volatile ETS components, and ETS-contaminated textile particulates are inhaled by non-smokers. Although numerous tobacco smoke-contained chemical compounds can be regarded as the ETS exposure marker, it is now believed that nicotine is the best marker in the qualitative and quantitative ETS assessment.

The aim of this study was to assess the nicotine sorption of textile polymers, polyamide and polypropylene, commonly used in TFC and to measure the nicotine elimination rate. The studies were carried out in a toxicological chamber (capacity of 45 dm³). The nicotine sorption from ETS-contaminated air and pure nicotine (Fluka) was investigated. Marlboro class A cigarettes were used to produce a tobacco smoke in the chamber. The decomposition kinetics of nicotine adsorbed by textile materials was also investigated as well as the possibility of accelerating the elimination of nicotine adsorbed by the textile material modified by titanium dioxide coated with nanosilver layer as the catalyst agent. Nicotine concentration was assessed using gas chromatograph (Agilent Technologies 6890N) equipped with a mass detector.

The studies showed that:

- polypropylene fibers manifest a higher nicotine sorption than polyamide fibers;
- nicotine-polluted polypropylene fiber particles inhaled by involuntary smokers may be the source of inhalation exposure;
- modification of polypropylene with titanium dioxide coated with nanosilver layer accelerates the elimination of nicotine adsorbed by the studied textile materials.

Acknowledgement

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Poster 13

The role of breath sampling as a tool for biological monitoring in occupational hygiene applications

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Monitoring of Volatile Organic Compounds (VOCs) in workplace air has become standard practice for a number of years, particularly in industries where they are widely used as solvents, fuels, raw materials, etc. However, a low atmospheric concentration of VOCs in the workplace does not necessarily mean that personal exposure levels will be low, as it is known that human exposure to these chemicals can occur via absorption through the skin and ingestion as well as inhalation.

For this reason, biological monitoring was introduced in order to identify any VOC exposure resulting from poor working practice or unsuitable protective equipment. Biological monitoring allows the actual body burden of VOCs to be measured, whatever the route of exposure, facilitating assessment of short term (acute) exposure and also providing an indication of chronic exposure. Biological monitoring methods have generally involved the study of urine or blood samples however the expensive and intrusive method of collecting these types of samples has prevented wide spread acceptance of biological monitoring as a routine environmental health and safety tool.

One alternative method of biological monitoring for VOCs is to sample the alveolar breath, which can indicate the presence of volatiles absorbed into the bloodstream. This paper presents an overview of how use of the BioVOC breath sampler for sampling alveolar breath, followed by analysis by thermal desorption (TD) GC(-MS) provides a non intrusive method of screening workers for exposure to potentially toxic VOCs. Data will be presented illustrating how screening of the workforce can highlight any potential incidences of high exposure.

Poster 14

RFID tagging for failsafe tracking of sorbent air monitoring tubes

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Concentration data for airborne chemicals is frequently collected as part of an overall environmental or workplace air monitoring strategy *i.e.* to ensure adequate air quality is maintained and/or that personal exposure limit levels are not exceeded. It is, therefore, important to minimize the risk of air monitoring data for different individuals or locations being mixed up.

Associating data with specific thermal desorption (TD) air monitoring tubes in the past has relied on manually recording tube serial numbers. Bar code technology has proved difficult to apply to TD tubes because the high temperatures required limit the lifetime of bar code labels. Moreover, bar codes cannot be programmed to record sample specific information (sorbent type, sampling time and date, *etc.*)

Recently, however, TD-compatible Radio Frequency Identification (RFID) technology has been introduced for sorbent tubes. This is designed to improve sample tracking between the laboratory and field monitoring locations *i.e.* to eliminate risk of monitoring data being wrongly assigned.

Details of the new tube tagging technology and its application to air monitoring, both for environmental and occupation hygiene studies, is presented in this paper.

Further application of RFID tube tags for tracking the history of individual sorbent tubes throughout their working life (number of thermal cycles, history of leak test failures, *etc.*) is also described as an aid to general analytical quality assurance.

Poster 15

Sampling method for simultaneous measurement of aerosols, inorganic acids and gases in workroom air

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A pumped personal sampling method for simultaneous measurements of mixed inorganic phases of aerosols, vapours and gases in workroom air has been established. The sampler consists of three different filters. The first stage collects non-volatile aerosol (particles, H_2SO_4 and H_3PO_4) on a membrane filter made of Teflon or PVC. The second stage consists of a cellulose filter impregnated with potassium hydroxide (KOH) to collect inorganic acids (HF, HCl, HNO_3 and sulphur dioxide (SO_2)). On a third filter, nitrogen dioxide (NO_2) can be collected on a cellulose filter impregnated with sodium iodine (NaI) and ethylene glycol.

The respective anions of the collected or reacted species were extracted from the filters by dissolution in deionised water and measured by ion chromatography (IC). IC provides the possibility to quantify many anions simultaneously in complex matrices. Methodology and figures of merits of the method will be reported.

Collection efficiencies were tested for HF and NO_2 using a novel laboratory vapour-generating system. Known amounts of diluted hydrofluoric acid were pumped into a vaporisation chamber and collected on impregnated filters to determine the breakthrough. Calibration gas with certified concentrations of NO_2 was used to determine the collection efficiency of NO_2 .

The method has been tested in aluminium potrooms, for welding operations and in the mineral fertilizer producing industry.

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