COST ACTION 633
Particulate Matter:
Properties Related to Health Effects

Proceedings of the international conference

Similarities and Differences in Airborne Particulate Matter:

Exposure and Health Effects over Europe

"Five interactive workshops"

Short Version

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Abstract

The impact of airborne particles on human health is currently seen as the most important environmental issue in Europe. Scientists with the diverse scientific background coming from all over Europe discussed the issue of “Particulate matter and health” in 5 interactive workshops.

Two main conclusions:

- There has been a tremendous increase in knowledge related to airborne particles and their effects on human health over the last decade: the complexity of PM is recognised and requires both new metrics and better understanding of source contributions for effective policy measures.
- Still, major knowledge gaps remain and it is seen that integrated approaches combining the different scientific areas covering environmental, socio-economic and medical research in selected regions in Europe are a prerequisite to effectively tackle the uncertainties European wide.

Specific needs were identified:

- Extension of the current monitoring network with additional particle parameters in urbanized areas.
- Improvement of PM mass measurement accuracy.
- Standardisation of analytical methods for aerosol measurements
- Better integration of epidemiology and toxicology, using for instance same health indicators (biomarkers of effect) with emphasize on oxidative stress.

Policy relevance was explicitly seen in the guidance on additional measures and abatement strategies from specific sources and in the explanation / increased confidence on biological plausibility and causal relationship by toxicology.

The need of collaboration and interdisciplinary approaches is obvious. Several urgent (definite) research needs were identified. A clear recommendation to conduct well organized concerted research studies in several regions in Europe comprising monitoring and research of air quality, exposure, health status, exposure-response functions, source specific toxicological studies as well as evaluation of abatement actions, was given by all members of COST 633 and participants of the workshop.

Preface

COST Action 633 was initiated by Othmar Preining and Helger Hauck with the support of the Clean Air Commission of the Austrian Academy of Sciences because of the clear need to address the topic "Particulate Matter and Health" through a multidisciplinary approach. Extensive knowledge and expertise was available in various relevant areas at the time, but interactions were often limited to experts within each of the fields of particle measurements, dynamics and transformation of atmospheric aerosols, epidemiology, toxicology and modelling of aerosol sources, atmospheric processing, exposure and health effects. Action 633 brings experts of these and other fields together and provides a truly interdisciplinary platform to formulate questions, discuss possible answers and identify research that needs to be performed in the near future and beyond.

The COST 633 conference provided an interdisciplinary discussion forum also to scientists and stakeholders who are not members of the MC or one of the working groups of the action. The results of our discussions form the main part of this scientific report.

The conference would not have been possible without the help and support of several institutions and persons. We are grateful to the Austrian Academy of Sciences for hosting the conference and for administrative support, the City of Vienna for the evening reception at the Vienna City Hall, and the University of Vienna for administrative support. The conference would not have been possible without the financial support given by the COST Office.

Gudrun Breschar of the Clean Air Commission of the Academy of Sciences was a great help with the administrative part of the conference at the Academy. Vera Meyer of the University of Vienna dealt with registrations, abstracts and other administrative issues. Peter Reisinger, Gerhard Steiner and Anna Wonaschütz helped with other preparations and provided on-site technical and administrative support at the conference. We are very grateful to them all – without their help and their dedication the conference would not have been the success it was.

As chair of the MC of COST 633 it is my great pleasure to express our gratitude to the topic leaders, rapporteurs and breakout group leaders for the efforts they put into the discussions and the report. Our heartfelt thanks go to the co-chairs of the program committee Flemming Cassee and Thomas Kuhlbusch for the hard work they did for the conference and the conference report – the Action thanks you for the success of the conference!

Regina Hitzenberger
Chair, Management Committee, COST 633

Executive Summary

COST Workshop 633 – Particulate Matter and Health

Similarities and differences in airborne particulate matter,

exposure and health effects over EuropeParticulate Matter and Health

The impact of airborne particles on human health is currently seen as the most important environmental issue in Europe. Recent assessments showed an expected loss in life expectancy of about 9 months in the year 2000 (EU-25, central CAFE baseline estimate[1]) due to exposure to (ambient) PM2.5 mass. The revisions of the Air Quality Directive and its daughter directives were discussed at the same time in Brussels which all form the background of this conference.

Various scientific areas covering a range of sciences from physics over chemistry, meteorology, engineering, toxicology, to epidemiology are necessary when tackling the still wide open issues in the research on particulate matter. Scientists with the diverse scientific background coming from all over Europe discussed the issue of "Particulate matter and health" in 5 interactive workshops. Each of which approached the conference topic "Similarities and differences in airborne particulate matter: Exposure and health effects over Europe" from a different perspective and resulted in answers to pressing (policy) questions.

The topics of the five workshops were:

1: Particle characterisation and characteristics
2: Sources of particulate matter
3: Modelling and (personal) exposure
4: Health effects - Epidemiology
5: Health effects - Toxicology

Figure 1 shows a flow chart on information and research areas necessary to assess the health impact of airborne particulate matter. It also illustrates how the topics fit into this overall scheme.

Two major issues were clearly stated by all participants of the workshop:

- There has been a tremendous increase in knowledge related to airborne particles and their effects on human health over the last decade: the complexity of PM is recognised and requires both new metrics and better understanding of source contributions for effective policy measures.
- Still, major knowledge gaps remain and it is seen that integrated approaches combining the different scientific areas covering environmental, socio-economic and medical

[1] Baseline Scenarios for the Clean Air for Europe (CAFE) Programme , Markus Amann, Imrich Bertok, Janusz Cofala, Frantisek Gyarfas, Chris Heyes, Zbigniew Klimont, Wolfgang Schöpp, Wilfried Winiwarter, Final Report to DG ENV, Feb. 2005

research in selected regions in Europe are a prerequisite to effectively tackle the uncertainties European wide.

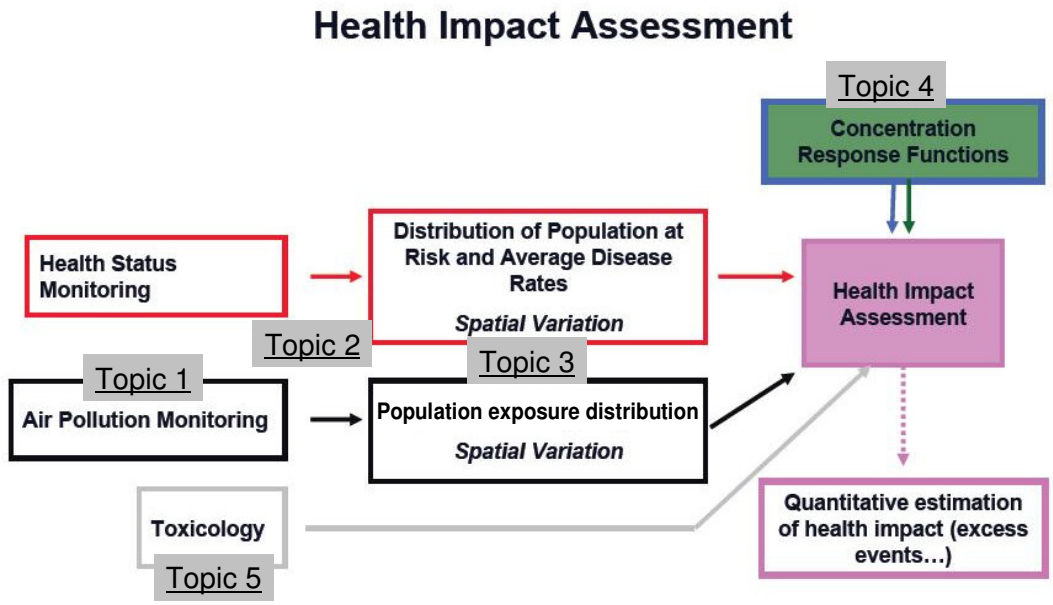

Figure 1: Scheme for health impact assessment [2]

Several major issues came up during the discussions in **workshop 1** on particle characteristics and characterisation. One block of recommendations is linked to monitoring. Specific needs were identified:

- Extension of the current monitoring network. Additional particle parameters should be measured and this with preference in urbanized areas.
- Improvement of PM mass measurement accuracy. Notably, the reference method EN12341 suffers from sampling artefacts and analytical bias.
- Standardisation of analytical methods for aerosol measurements that cannot be validated because standards do not exist (e.g. EC, particle number concentration).
- Better integration of epidemiology and toxicology, using for instance same health indicators (biomarkers of effect) with emphasize on oxidative stress.

The points listed above would be best addressed by setting up at least 3 aerosol (super) sites in urban areas located in different regions of Europe. These (super) sites would achieve a complete characterisation of the urban aerosol in relation with their health effect, and serve as platforms for instrument calibrations and intercomparisons.

[2] Analysis and design of local air quality measurements: Towards European Air Quality Health Effect Monitoring, T. Kuhlbusch, A. John, A. Hugo, A. Peters, S. Klot, J. Cyrys, H.-E. Wichmann, U. Quass, P. Bruckmann, Report to DG ENV, http://www.iuta.de/Verfahrenstechnik/Luftreinhaltung/euraqhem_final_report.pdf, April 2006.

Further important recommendations were

- Development of novel analytical capabilities related to aerosol-and-health e.g. PM oxidative stress potential, reactivity or the surface area of the particles' insoluble core.

Specific relevance to policy developments:

- Assessment of how pollutant emission abatement strategies affect PM characteristics.
- Guidance on the selection of new parameters to be measured for monitoring the health effects of PM.

The above recommendations are all linked to ambient air quality monitoring and its assessment while in **workshop 2** the main focus was on the sources of airborne particulates and their assessment. The importance of source apportionment in view of health effects and planning of abatement strategies was clearly stated. The following issues were identified to be of high importance for the future directions of source apportionment.

- A need for the development of a common methodology for certain questions/tasks is clearly seen, which shall be validated by comparison with secondary information and/or other methods.
- A possible new focus could be the combination of emission inventories, chemical transport models and source apportionment methods into an integrated approach. While each tool separately is not capable of answering all questions, in combination they could provide a more detailed insight to issues such as regional variability of contributions by traffic, wood burning, etc.
- The quantification of wood burning as a PM source is a concern for emission inventories. Source apportionment studies could help verifying or rejecting the current statistics, in order to determine whether the large differences reported across the EU are a fact or whether wood burning is simply not reported for some regions.
- One of the biggest challenges for source apportionment studies are secondary organic aerosols (SOA). Current knowledge on their formation processes and on the influence of natural or anthropogenic precursors is limited. Smog chamber experiments, modelling studies or the study of their polymerisation processes would provide an insight to this issue.

Linking source apportionment and health effect studies was identified to be of specific importance which should include the following points:

- Separate focus on the coarse and fine grain-size fractions, given that the health effects associated with these two fractions need to be differentiated (respiratory vs. cardiovascular).
- Extension to particle number concentrations, namely ultra fine particles.
- Short- and long-term health effect studies should be linked to source apportionment studies, thereby facilitating the identification of possibly harmful sources and particle properties.

Following recommendation was giving with specific regards to policy issues.

- Source apportionment studies shall be conducted for verification of the effects of the various European and local abatement efforts.

While ambient air and particle source apportionment studies are important tools linking particles and health a further major focus discussed in **workshop 3** was the linkage of measurements of (personal) exposure and how modelling can facilitate this linkage. The intense discussion of this topic enabled the identification of the following recommendations:

- There is a need to assess the uncertainty of existing models rather than to develop new models.
- Long-term exposure estimates need to be improved and developed, especially taking the indoor situation into account.
- Outdoor-indoor penetration of particles and their life time as well as indoor sources and their association with health effects require further investigations.
- Air quality models should be used to complement monitoring data allowing a better spatial distribution characterisation and hence enable improved exposure assessments.
- Exposure studies in Europe should take into account the different characteristics of climate zones, the specific behaviour of social groups, and regional habits.

Again, specific recommendations with regards to policy developments were identified to be:

- Assessment of transboundary transport of PM with advanced air quality models
- Increase number of PM parameters in air quality model outputs to include more health relevant parameters e.g. trace constituents, source contributions, ultra fines.
- Guideline values based on exposure rather than ambient concentrations are needed to improve public health.

The last two workshops were complementary to the first three. The first three were focussed mainly on the different aspects of exposure (air quality monitoring, source apportionment, indoor/outdoor, air quality modelling, personal exposure) while the focus of the last two was on health effects related to particle exposure. Epidemiology, its possibilities and limitations were discussed in **workshop 4**. The outcomes of this discussion are summarized in the statements below identifying future needs and possible directions.

- Physicochemical differences of particles need to be better defined and included into health effect models that include genetic and socio-economic differences.
- Development of high resolution spatial exposure models for the estimation of chronic, long-term particle exposure; studies in selected regions in Europe on long-term effects of air pollution with standardized procedures in both health and exposure assessment are needed. To appropriately investigate chronic effects, such studies must focus on early pathophysiological or functional markers of chronic diseases rather than on terminal outcomes.

- Inclusion of socio-economic and genetic differences in studies on exposure-response relationships between air pollution and pulmonary, cardiovascular or neurodegenerative diseases. The interrelation between socio-economic factors and the biologically relevant co-factors are poorly understood in different regions of Europe and need to be integrated in future air pollution research.
- Development of dosimetry models that can be used to refine the exposure-response function and for studying effects in secondary organs.
- Investigation of the consistency of concentration-dose-effect estimates for different sources, constituents, and European regions.

Major issues related to policy developments needs are seen to be:

- Abatement strategies need to be evaluated by integrated health effect studies concurrently with the time line of their integration.
- Integrated short-term health effect studies linking health effects and sources are needed to identify their potential hazards. This will allow for initiation of new effective measures.

The last **workshop 5** dealt with health effects mainly from the toxicological point of view. Clear concepts on how particle interact with human health were presented while major gaps were identified at the same time. Further needs of developments are seen for in the following aereas:

- Better integration of epidemiology and toxicology, using for instance same health indicators (biomarkers of effect).
- Conduct source related toxicological studies preferably using real world mixed samples of different regions of Europe.
- Long term exposure studies (that can also be used as toxicology-time series studies). Better animal models with the challenge for developing and using transgenic mouse models.
- Development of a test battery for oxidative stress that can ultimately be used to monitor the biological reactivity of air pollution in different regions of Europe.
- Development of tests to evaluate the effectiveness of control strategies e.g. for vehicle and wood combustion emissions.
- The role of the surface area of (the insoluble core of) PM has to be identified.
- The role of so-called non-toxic components (often also referred to as “natural”) in the total mixture of PM in view of health effects is still insufficiently studied. Can such particles interact to become cariers for toxic or allergic substances?
- Integration of air sampling in toxicological studies: Usage of PM sampling techniques that reduces sampling artefacts to a minimum such that it approaches the real-world situation of PM in the human airways.

Policy relevance was explicitly seen in the guidance on additional measures and abatement strategies from specific sources and in the explanation / increased confidence on biological plausibility and causal relationship by toxicology.

The need of collaboration and interdisciplinary approaches became obvious during the final discussion. Several urgent research needs were identified in specific research areas and a clear recommendation to conduct well organized concerted research studies in several regions in Europe comprising monitoring and research of air quality, exposure, health status, exposure-response functions, source specific toxicological studies as well as evaluation of abatement actions, was given by all members of COST 633 and participants of the workshop.

Conference Participants