Air quality and human health – the urban environment perspective

Dorota Jarosinska
European Environment Agency

International Meeting on Health and Environment: Challenges for the Future
Istituto Superiore di Sanità, Rome, December 9 - 11, 2009
About EEA

EEA mandate:

To help the Community and member countries make informed decisions about improving the environment, integrating environmental considerations into economic policies and moving towards sustainability.
EEA’s main tasks

- **Networking** - Development of a European Environmental Information and Observation Network (EIONET)
  
  www.eionet.europa.eu

- **Reporting** on the state and trends of Europe’s environment
  
  www.eionet.europa.eu/reportnet.html

- Providing **access to environmental information**
  
  http://dataservice.eea.europa.eu
Up-to-date information and assessments

http://www.eea.europa.eu
Exposure to air pollution in EEA 32 Member countries

Period 1997-2007:

20-50% of the urban population was potentially exposed to PM10 concentrations in excess of the EU limit value

15-41% of the urban population was potentially exposed to NO₂ concentrations above the EU limit value

15-60% of the urban population in Europe was exposed to ambient ozone concentrations exceeding the EU target value

Both for PM10 and ozone the fraction varies strongly during the period reflecting the importance of meteorological variations

http://themes.eea.europa.eu/IMS/ISpecs/ISpecification20080701123452/IAssessment1243521792257/view_content
Percentage of urban population in EEA Member Countries exposed to air pollution above the limit/target value

http://themes.eea.europa.eu/IMS/ISpecs/ISpecification20080701123452/IAssessment1243521792257/view_content
Assessment of ground-level ozone within EEA Member Countries with focus on long-term trends

In general, ambient air measurements in urban as well as in rural areas do not show any downwards trends in ground-level ozone in Europe over the last decade, although anthropogenic $O_3$ precursor emissions in Europe have been reduced significantly.
Trends of primary and secondary pollutant concentrations in Finland in 1994–2007

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The trends in the atmospheric concentrations of the main gaseous and particulate pollutants in urban, industrial and rural environments across Finland were estimated for the period of 1994–2007. The statistical analysis was based on generalized least-squares regression with classical decomposition and autoregressive moving average (ARMA) errors, which was applied to monthly-averaged data. In addition, three alternative methods were tested. Altogether 102 pollutant time series from 42 sites were analyzed. During the study period, the concentrations of SO₂, CO and NOₓ declined considerably and widely across Finland. The SO₂ concentrations at urban and industrial sites were approaching background levels. The reductions in NOₓ and CO concentrations were comparable to those in national road traffic emissions. A downward trend was detected in half of the NO₂ time series studied, but the reductions were not as large as would be expected on the basis of emission trends, or from NOₓ concentrations. For O₃, neither the mean nor peak values showed large changes in background areas, but were increasing in the urban data. For PM₁₀, five of the 12 urban time series showed decreasing mean levels. However, the highest concentrations, typically attributable to the problematic springtime street dust, did not decrease as widely. The reduction of the long-range transported major ions, mainly driven by the large-scale reduction in sulphur emissions, possibly plays a significant part in the decreases in the mean PM₁₀ concentrations. It was shown that the handling of the serially-correlated data with the ARMA processes improved the analysis of monthly values. The use of monthly rather than annually-averaged data helped to identify the weakest trends.
Exposure to anthropogenic particulate matter and ozone was associated with 380,000 premature deaths in Europe in 2000
Air quality and Health

Projected emission reductions expected to significantly reduce impacts on public health and ecosystems

Loss of statistical life expectancy (months) due to anthropogenic PM$_{2.5}$ - projected emission levels for 2020

EEA, 2007
Number of premature death per million inhabitants attributable to PM10 exposure

Note: The 'no ex scenario' corresponds to the (hypothetical) situation that the daily limit value were not exceeded at European hot-spot locations.
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EEA, 2009
Focus on urban environment

75 % of Europeans live in urban areas now
80 % expected to live in urban areas in 2020

Increasing trend due to:
rural to urban migration (short term), immigration, also triggered by the effects of climate change (longer term)

Local variability within this overall pattern in Europe:
~1/3 of cities grew between 1996 and 2001
~1/3 of cities witnessed stable populations
~1/3 of cities experienced decline in population
Emissions of regulated air pollutants from vehicles continue to fall across EEA member countries but concentrations remain high in some urban areas.

Despite a reduction in road transport exhaust emissions across Europe, there have been no significant improvements in concentrations of fine particulates (PM10) and nitrogen oxides (NOX), which have a major impact on air quality and human health.

In response, integrated approaches including low emission zones are being introduced.
Transport emissions of regulated air pollutants in EEA member countries

Exceedances of annual average air quality objectives caused by traffic

**Graph**

- **Index (1990 = 100)**

- **Data for years:** 1990 to 2006

- **Graph lines:**
  - Green: Ozone precursors
  - Yellow: Particulate matter (PM$_{10}$)
  - Purple: Acidifying substances

**Notes**

- **Source:** European Topic Centre for Air and Climate Change, 2008.

**Bar Chart**

- **X-axis:** Years (1999 to 2006)
- **Y-axis:** μg/m$^3$

- **Bars:**
  - Red: NO$_2$
  - Pink: PM$_{10}$

**Note:** Columns indicate mean values while error bars indicate maximum values.

**Source:** European Topic Centre for Air and Climate Change, 2008.
Traffic related air pollution should be a key target for public health in Europe

Künzli et al., 2000
Rotterdam region – contributions to NO$_2$ and PM$_{10}$ from different sources, 2000

EEA, 2009
Oxidative properties of ambient PM$_{2.5}$ and elemental composition:
Heterogeneous associations in 19 European cities

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ABSTRACT

We assessed the extent to which constituents of PM$_{2.5}$ (transition metals, sodium, chloride) contribute to the ability to generate hydroxyl radicals (•OH) in vitro in PM$_{2.5}$ sampled at 20 locations in 19 European centres participating in the European Community Respiratory Health Survey. PM$_{2.5}$ samples ($n = 716$) were collected on filters over one year and the oxidative activity of particle suspensions obtained from these filters was then assessed by measuring their ability to generate •OH in the presence of hydrogen peroxide. Associations between •OH formation and the studied PM constituents were heterogeneous. The total explained variance ranged from 85% in Norwich to only 6% in Albacete. Among the 20 centres, 15 showed positive correlations between one or more of the measured transition metals (copper, iron, manganese, lead, vanadium and titanium) and •OH formation. In 9 of 20 centres •OH formation was negatively associated with chloride, and in 3 centres with sodium. Across 19 European cities, elements which explained the largest variations in •OH formation were chloride, iron and sodium.

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Polycyclic aromatic hydrocarbons in size-segregated particulate matter from six urban sites in Europe

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Polycyclic aromatic hydrocarbons (PAHs) were investigated in size-segregated particulate samples collected in a series of 7-week sampling campaigns in Europe 2002–2003. The principal objective of the study was to provide new insight into the distribution of PAHs between ultrafine, fine and coarse particle size ranges during different particulate pollution situations in Europe. The samplings were conducted in urban background sites of six cities: Duisburg, Germany (autumn), Prague, Czech Republic (winter), Amsterdam, The Netherlands (winter), Helsinki, Finland (spring), Barcelona, Spain (spring) and Athens, Greece (summer). Particulate samples were collected in 3- and 4-day periods per week using a high volume cascade impactor (HVCI). 32 PAHs were analysed from pooled samples in ultrafine ($\text{PM}_{0.2}$), fine ($\text{PM}_{0.2-2.5}$) and coarse ($\text{PM}_{2.5-10}$) size ranges. The campaigns showed different PAH profiles, not only by concentration but also by detailed PAH composition. The PAH concentrations were high ($\text{PM}_{10}$-PAH 9.9–55 ng m$^{-3}$) in the autumn and winter campaigns compared to spring and summer samples ($\text{PM}_{10}$-PAH 2.9–5.2 ng m$^{-3}$). In Prague, the PAH contribution was the highest in $\text{PM}_{0.2}$, whereas in the five other cities the PAH contribution was the highest in $\text{PM}_{0.2-2.5}$. PAHs with four rings had a large contribution (41–47\% of total PAH concentration in $\text{PM}_{10}$) to the total PAHs in each of the campaigns. In cold-season campaigns, the contributions of the 5- and 6-ring PAHs, many of which are suspected carcinogens or genotoxic agents, became prominent in the fine (28–45\%) and ultrafine (41–65\%) size ranges. The representativeness of benzo[a]pyrene as a marker of total and known carcinogenic PAHs was poorer than that of benzo[k]fluoranthene.
Biomass burning in Europe – a re-emerging issue?

CARBOSOL project (FP5)

High levels of air pollution from residential wood burning in winter season in Europe

50-70% carbon in the atmosphere derived from biomass burning

Germany

A proposal to introduce limit values for particulate matter and CO emissions from small wood burning stoves (2008)
Comparison of particle emissions from small heavy fuel oil and wood-fired boilers

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\textbf{ABSTRACT}

Flue gas emissions of wood and heavy fuel oil (HFO) fired district heating units of size range 4–15 MW were studied. The emission measurements included analyses of particle mass, number and size distributions, particle chemical compositions and gaseous emissions. Thermodynamic equilibrium calculations were carried out to interpret the experimental findings.

In wood combustion, PM\textsubscript{1} (fine particle emission) was mainly formed of K, S and Cl, released from the fuel. In addition PM\textsubscript{1} contained small amounts of organic material, CO\textsubscript{2}, Na and different metals of which Zn was the most abundant. The fine particles from HFO combustion contained varying transient metals and Na that originate from the fuel, sulphuric acid, elemental carbon (soot) and organic material. The majority of particles were formed at high temperature (>800 °C) from V, Ni, Fe and Na. At the flue gas dew point (125 °C in undiluted flue gas) sulphuric acid condensed forming a liquid layer on the particles. This increases the PM\textsubscript{1} substantially and may lead to partial dissolution of the metallic cores.

Wood-fired grate boilers had 6–21-fold PM\textsubscript{1} and 2–23-fold total suspended particle (TSP) concentrations upstream of the particle filters when compared to those of HFO-fired boilers. However, the use of single field electrostatic precipitators (ESP) in wood-fired grate boilers decreased particle emissions to same level or even lower as in HFO combustion. On the other hand, particles released from the HFO boilers were clearly smaller and higher in number concentration than those of wood boilers with ESPs. In addition, in contrast to wood combustion, HFO boilers produce notable SO\textsubscript{2} emissions that contribute to secondary particle formation in the atmosphere. Due to vast differences in concentrations of gaseous and particle emissions and in the physical and chemical properties of the particles, HFO and wood fuel based energy production units are likely to have very different effects on health and climate.

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Outdoor and indoor air – two distinct entities?

Modern European citizens spend, on average, over 90% of their time indoors

Indoor air originates from outdoors; some pollutants are effectively transferred indoors (e.g. PM2.5, P = 50–90%), other react with indoor air co-pollutants (e.g. O3)

Indoor environments contain sources of contaminants, which, due to the low indoor air exchange rates compared to outdoor environment, may lead to quite high levels

The combination of the generally higher indoor concentrations and the fraction of time spent indoors results in the overall domination of indoor air in air pollution exposures regardless of their sources.
Flowchart of the EnVIE project

1. Effects
- Asthma symptoms
- Atopic dermatitis, rhinitis, conjunctivitis
- Respiratory infections
- Lung cancer
- COPD
- Cardiac or cardiovascular acute effects
- Acute/chronic poisoning
- ‘SBS’ symptoms

2. Exposures

3. Sources
- Outdoor air pollutants
- Soil
- Building, equipment, ventilation
- Indoor materials, carpets, furnishings
- Indoor combustion devices
- Tobacco
- Consumer products (cleaning, treatment)
- Pets, humans, insects, plants
- Water damage

4. Policies

‘X, X, X’ denote different levels of impact. ‘2’ denotes secondary influences.
EnVIE project – estimated health impacts and potential health benefits

2.2 mln DALYs (disability adjusted life year) per year roughly attributed to indoor air quality (excluding ETS)

Controlling penetration of outdoor air to indoor air can result in major health benefits (estimated 890 000 DALYs)

Other measures with potential health benefits:
- reduction of radon exposure;
- inspections of cooking, heating, and combustion;
- prevention of dampness;
- waterproof surfaces;
- and perfect ventilation.
EnVIE project – estimated health impacts and potential health benefits

Integration of IAQ requirements into European Energy Performance of Buildings Directive could reduce contamination of indoor air from outdoor/indoor pollutants and result in reduced BoD (estimated 960 000 DALYs).

High level of uncertainty in these estimates and differences in feasibility of various solutions.

Some solutions are relatively easy to implement, while others are costly and time consuming.

Some policies relevant for IAQ are interdependent; some even contradictory.
WHO GUIDELINES FOR INDOOR AIR QUALITY

DAMPNESS AND MOULD
Associations between indoor dampness-related agents and health outcomes

**Sufficient epidemiological evidence of increased risk of respiratory symptoms, infections and exacerbation of asthma**

**Some evidence suggesting increased risks of allergic rhinitis and asthma**

**Clinical evidence of risks of rare conditions: hypersensitivity pneumonitis, allergic alveolitis, chronic rhinosinusitis and allergic fungal sinusitis**

**Toxicological evidence of inflammatory and toxic responses after exposure to microorganisms (spores, metabolites, etc), isolated from damp buildings**

**Atopic and allergic people are particularly susceptible to biological and chemical agents in damp indoor environments, but adverse health effects have also been found in non atopic populations**
Global trends relevant for indoor exposure to dampness and mould

**Energy conservation** measures that are not properly implemented (ventilation deficits, improper insulation)

**Urbanization** (migration, building types / density, urban degradation, housing availability and social inequity)

**Climate change** (increasing frequency of extreme weather conditions, shifting of climate zones)

**The quality** and globalization of **building materials** and components, **construction concepts** and **techniques**
Climate Change starts at home!
Energy is the unique environmental pressure factor that crosses all environmental levels

- **Global**
  - Climate change
  - Biodiversity

- **Regional**
  - Atmospheric pollution
  - Landscaping

- **Local**
  - Microclimate
  - Morphology

- **Interior**
  - Indoor air quality
  - Comfort
  - Energy use & CO₂ emissions

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<td>energy vs CO₂ production</td>
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European Environment Agency

de Oliveira Fernandes, 2008
Multiple exposure

Sources
 Policies
 Health effects

Noise
Air pollution
Integrated approach to noise and air pollution

Advantages of an Integrated Air Quality and Noise Abatement Plan and its Implementation
– Experiences from Berlin –

Annette Rauterberg-Wulff

Senate Department for Health, Environment and Consumer Protection, Berlin

...based on the analysis of different legal requirements and on potential commonalities in parameters required for noise mapping and for air pollution analyses...
‘... No study has yet incorporated exposure to both noise and air pollution, making it difficult to disentangle effects by the two types of exposure’

Selander et al., 2009
(in a study on long-term exposure to road traffic noise and myocardial infarction)
Environmental and social stressors – possible combined impacts

Environmental pollution, e.g. traffic-related air pollution is often spatially associated with noise, poverty, and other stressors

Social stressors may lead to poor health outcomes directly or may increase susceptibility to physical exposures

The most pollution-exposed communities may also be more susceptible because of higher prevalence of social stressors

Clougherty and Kubzansky, 2009
A framework for examining social stress and susceptibility to air pollution in respiratory health—review of evidence

Tremendous work still needs to be done to understand the combined and potentially synergistic health effects of stress and air pollution

- Relative temporalities of stress and pollution exposures
- Nonlinear, threshold, and saturation effects
- Physiologic pathways not elucidated by epidemiologic studies
- Relative spatial distributions of social and physical exposures at multiple geographic scales
Air quality and climate change – exploring co-benefits of an integrated approach

Climate change and urban air quality problems have common drivers, such as urbanization, population growth, mobility, energy consumption.

Both GHG and air pollutants concentrations tend to increase.

Both climate change and urban air quality problems impact human health, ecosystems, and economics.
Climate variability and change has contributed to an increase in average ozone concentrations in central and South-Western Europe (1–2 % per decade)

During the summer of 2003, exceptionally long-lasting and spatially extensive episodes of high ozone concentrations occurred; appear to have been associated with the extraordinarily high temperatures over wide areas of Europe and illustrate the expected more frequent exceedance of the ozone threshold under projected climate change

The projected climate-induced increase in ozone levels may result in current ozone abatement policies becoming inadequate
Observed changes in warm spells and frost days indices 1976–2006

Observed changes in duration of warm spells in summer (left) and frequency of frost days in winter (right), in the period 1976–2006

Source: The climate dataset is from the EU-FP6 project ENSEMBLES (http://www.ensembles-eu.org) and the data providers in the ECA&D project (http://eca.knmi.nl).
Daily mortality and apparent temperature

EEA, 2008, after McMitchell et al., 2006
Large reductions in air pollution are still achievable, with consequently similar improvements in public health from air pollution (by reducing emissions and limiting traffic activity)

There is increasing recognition of hemispheric nature of air quality problems – particularly O3 and to some extent PM - and the links with climate change

The geographical coverage of the debate on air quality should broaden in scope and involve a wider range of source sectors

Significant synergies and co-benefits are possible through a concerted consideration of air quality and climate change policies
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YOUR RATING: MODERATE

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Irritating, Dirty, Non-irritating, Clear, Clean, Odourless, Non-clear, Smelly

OUR RATING: GOOD
YOUR RATING: GOOD

22 Ratings

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