AirMonTech

Air Pollution Monitoring Technologies for Urban Areas

National and Kapodistrian University of Athens

Options for integration of air quality and health effects monitoring

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Why is air quality monitored?

Most would answer: to monitor compliance with the legislation

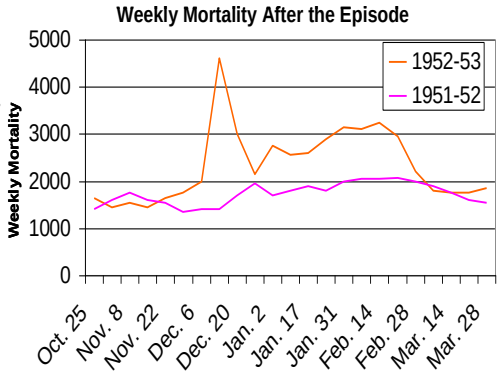
But why is there legislation to keep the concentrations of some air pollutants low?

Because there is scientific evidence that there are adverse health effects when the concentrations are "high".

Which level is "high" is again determined by toxicological or epidemiological studies.

Older vs more recent situation in Europe

•During the first decades of the 20th century, when very severe pollution episodes happened, the health effects were so devastating, that no sophisticated methodology was needed to actually persuade anyone that there were indeed health effects and there was a need for control (the relatively accurate quantification of the effect was something more ambivalent) .

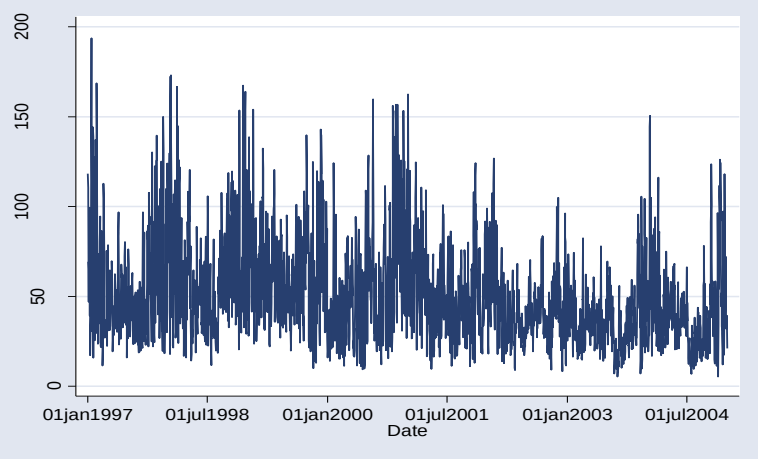


•From these episodes came the first realization of the problem and the first regulatory attempts, which led to a decrease of several air pollutants concentrations in many European areas.

•After a latent period, during which the general consensus was that those decreased air pollutants concentrations were not affecting health, around the late 80s and 90s, better designed and analyzed epidemiological studies (U.S. and EU) slowly accumulated evidence that there were still short-term effects on health (e.g. Hatzakis et al 1986; Schwartz & Dockery 1992; Schwartz 1993)

What data did those studies use?

They used the measurements available from the monitoring networks, at that time mainly measuring Black Smoke (BS) in Europe; TSP and later PM_{10} in the US.



- The accumulation of this evidence led to more studies.
- The main conclusion was about the existence of adverse effects of Particulate Pollution.
- The evidence started being consolidated with experimental and toxicological results and with the first major studies on long-term health effects. The first was the Harvard 6-cities study (Dockery et al 1993), where the measurements in the six cities were done by the researchers ($PM_{2.5}$ and PM_{10}).

An operational classification of the adverse effects of air pollution on health is in short-term effects (same day, or up to a few days) and long-term effects (years or life-long).

Their study requires different designs which have different requirements for exposure measurements:

For the study of short-term effects a fine time resolution is needed (typically daily measurements, e.g. 24h PM_{10} concentrations; max 1-hour ozone concentration for every day)

For the study of long-term effects a fine spatial resolution is needed (e.g. measurements in various areas within a city, complemented by appropriate models to downscale to every point within an area)

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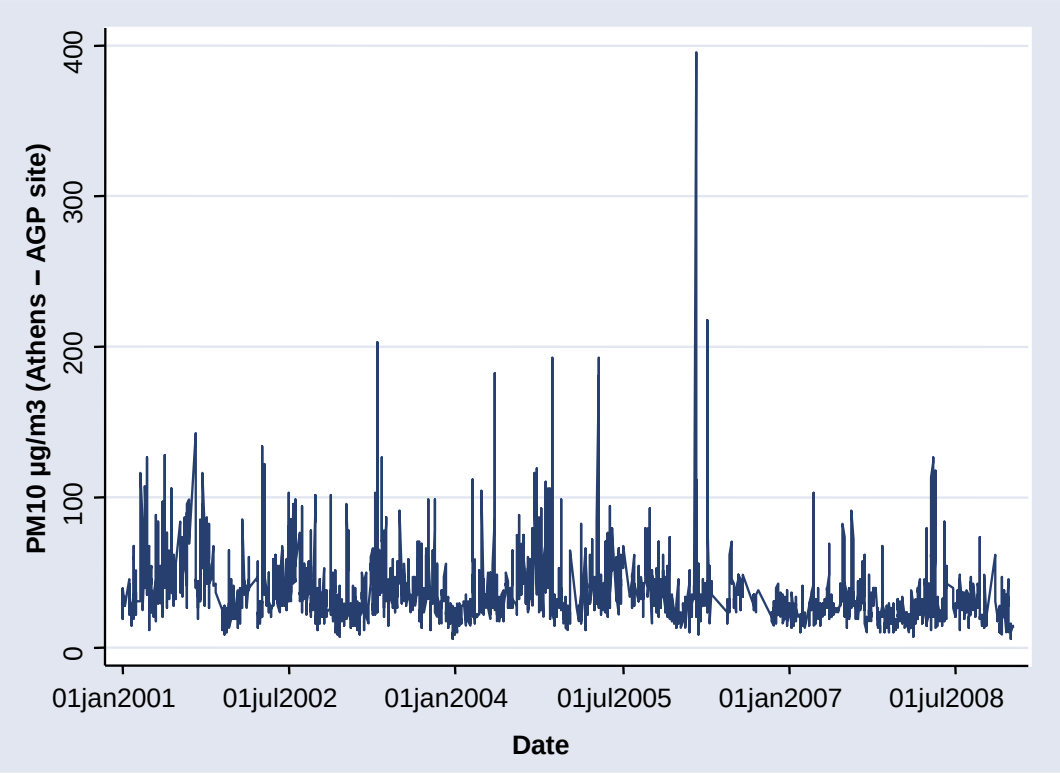

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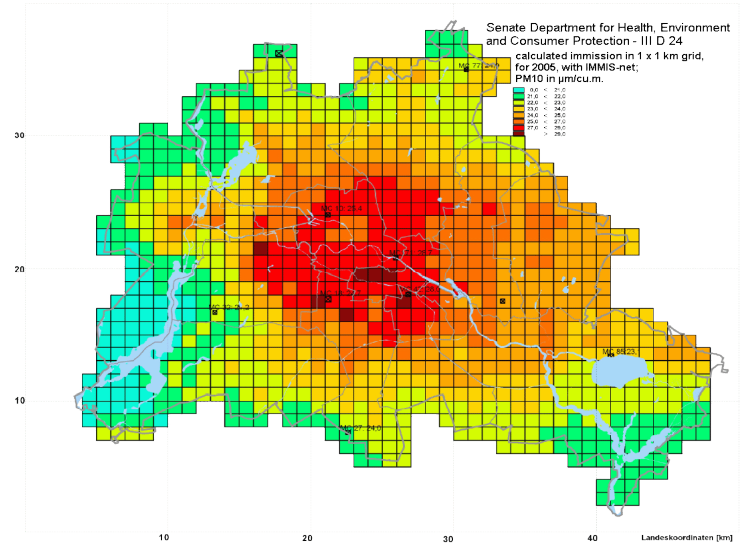
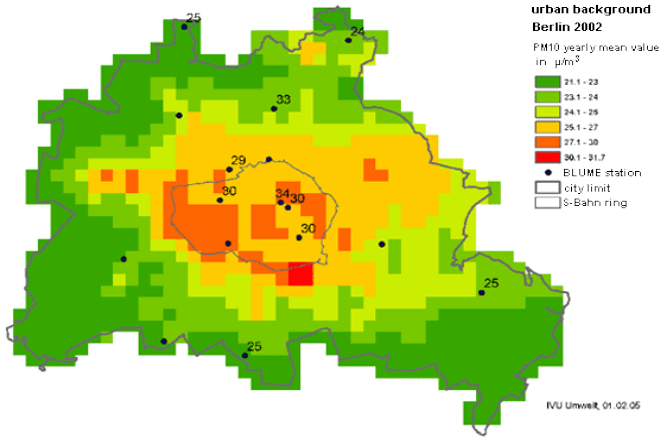
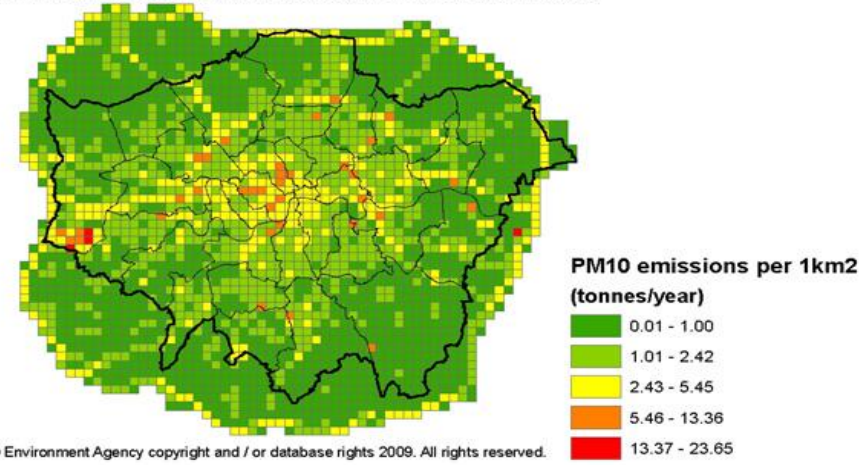




Emissions of Particulate Matter with a diameter less than 10 µm (PM10) from all sources across the Greater London area in 2006

Source: London Atmospheric Emissions Inventory 2006, Greater London Authority

Environment Agency



The EU regulated BS until 1999 and PM_{10} thereafter.
$PM_{2.5}$ was added in 2008.

The USEPA regulated TSP until 1987 and PM_{10} thereafter.
$PM_{2.5}$ was added in 1997.

In the next few slides, I will show results from well known studies, to illustrate how the regulations affected the reported results.

Short-term effects of PM_{10} on health. Results from the multi-city U.S. (H.E.I funded) project "National Mortality, Morbidity and Air Pollution Study" (NMMAPS) Samet et al 2000; NEJM 343: 1742-9

Mortality	% (95% CI) increase in outcome per 10μg/m^3 increase in PM_{10}
All natural causes	0.5 (0.1-0.9)
Cardio-respiratory causes	0.7 (0.2, 1.2)

Short-term effects of PM on health. Results from the multi-centre European project "Air Pollution and Health: a European Approach" (APHEA2)

	% (95% CI) increase in outcome per 10μg/m^3 increase in pollutant	
Mortality	PM_{10} or TSP*	Black smoke
All natural causes (APHEA2, 21 cities, lags 0 and 1; Epidemiology 2001; 12: 521-31)	0.6 (0.4-0.8)	0.6 (0.3-0.8)
Cardiovascular causes (APHEA2 , 21 cities, lags 0 and 1; Epidemiology 2006;17:230-3)	0.8 (0.5, 1.1)	0.6 (0.4, 0.9)
Respiratory causes (APHEA2 , 21 cities, lags 0 and 1; Epidemiology 2006;17:230-3)	0.6 (0.2, 1.0)	0.8 (0.1, 1.6)

* PM_{10} was mostly calculated from fragmented measurements and modeled estimations, to produce comparable data

U.S. ACS study: Adjusted mortality relative risks (RR) associated with 10μg/m^3 change in $PM_{2.5}$*
(Pope et al, 2002)

Cause of mortality	RR* (95% CI)
All cause	1.06 (1.02 – 1.11)
Lung cancer	1.14 (1.04 – 1.23)
Cardiopulmonary	1.09 (1.03 – 1.16)
All other cause	1.01 (0.95 – 1.06)

*Adjusted for age, sex, race, smoking, education, marital status, body mass, alcohol consumption, occupational exposure, diet.

Adjusted mortality relative risks (RR) associated with 10μg/m^3 change in Black Smoke and 30μg/m^3 change in NO_2 from the Netherlands cohort study (Hoek et al 2002)

Cause of mortality	Black Smoke RR (95% CI)	NO_2 RR (95% CI)
All cause	1.31 (0.95-1.80)	1.25 (0.83-1.89)
Cardiopulmonary	1.71 (1.10- 2.67)	1.81 (0.98-3.34)
Non-cardiopulmonary non-lung cancer	1.09 (0.71-1.69)	1.08 (0.63-1.85)

Comparison of effect estimates of European Cohort Studies, for NO_2 or NO_x per 10 $\mu g/m^3$

	All cause	Cardio pulmonary
Nafstad (NO_x) 2004 (Norway)	1.08 (1.06 – 1.10)	1.23 (resp) (1.13 – 1.35)
Hoek (NO_2) 2002 (the Netherlands)	1.12 (0.98 – 1.33)	1.27 (1.00 – 1.78)
Filleul (NO_2) 2005 (France)	1.14 (1.05 – 1.17)	1.27 (1.04 – 1.56)

Clearly the number & the quality of studies, as well as the kind of the results provided (i.e. which PM index is studied) depend on the measurements made available to the researchers by the established routine monitoring networks.

So far the decision makers regulating the routine air pollution monitoring in Europe have not been responsive to the needs of research.

They request adequate evidence on health effects before a regulation is introduced.

However, adequate evidence can only be produced when adequate measurements become available.

Some of today's open questions in specifying the health effects of air pollution are:

- Which physical and chemical PM characteristics are the most important for human health?
- Are PM from various sources different in terms of their health effects?
- How (i.e. where and when) do people get exposed?
- Is there interaction between the various aspects of pollution and/or between these and socioeconomic, climatic and other factors, in shaping the health effects?

To answer these questions specific measurement needs arise

- Measurements (on the exposures of interest) with time and spatial resolution.
- Measurements in microenvironments
- Personal measurements
- Data on population time-activity patterns

The scientific community responded

The scientific community responded by doing ad hoc measurement campaigns for the needs of specific studies (e.g. the ESCAPE project)

This is more easily done for the requirements of long-term effect studies, where the need focuses on the long-term estimation of personal exposure. However, the production of relevant health data is more difficult and expensive for these studies.

It is more expensive to produce daily time-series for the needs of assessing short-term effects. However, here the production of relevant health data is much easier and cheaper.

Data is now available from specific project campaigns

- But these data are fragmented in time and space
- They are not easily comparable
- They are often not possible to combine to yield powerful results
- An recent example illustrates an effort to find and combine data on untrafine particles, where the time periods are in some instances interrupted, the measurement devices are different, the placement of monitors not comparable etc.

What solutions can we propose? (1)

- Clearly the official EU monitoring guidelines and requirements are in a unique position to help yield the necessary exposure data which will form the basis for filling in the knowledge gaps.

- As a first step, more interaction between decision makers and exposure specialists on the one hand and health researchers on the other should be established (e.g. AirMonTech!), that is, a continuous multi-disciplinary interaction at the decision-taking level.

- The target, from the health research point of view, is to assess personal air pollution exposure (for those pollutants or mixtures of pollutants that interest us) with high time and spatial resolution.

What solutions can we propose? (2)

- Not all monitoring systems and sites can provide the same time and space density of information.

- The creation of "supersites" or "special" sites should be considered.

- Mobile measurement units may be employed to complement the fixed site measurements in specific situations, designed in collaboration with health researchers

What solution can we propose? (3)

- Exposure studies done ad hoc, but in a coordinated way, in various representative population samples, using smart-phone technology and sensors to record individual location and exposure, can provide input to generate appropriate models for predicting exposure, when combined with routine measurements, to all members of a population.

- Their data can also be used to validate models (e.g. dispersion models or models using remote sensing data).

Furthermore, the collaboration of communities can be achieved and lead to better prevention

- Individuals can be informed about the air pollution conditions, the contribution of the various mobility and activity patterns to their exposure levels and protect themselves better

London Air on Android