Study on good practices in policies of intervention in European Union countries

1. Introduction

Air quality, especially in urban areas, deteriorated with the industrial revolution and the following centuries, but it is only during the last 60 years that the health impacts of air pollution have been recognised and acted upon. The evaluation of current research within the Clean Air for Europe (CAFE) process has clearly shown that investments in further air quality improvements will have a beneficial return financially, in terms of population health, environmental improvements and in quality of life [1].

The measurement of air quality changed dramatically during the last century reflecting the concurrent knowledge about the adverse effects of air pollution, as well as through technological developments. The earliest measurement methods can be traced back to the Montsouris Observatory in Paris, where ozone was measured between 1876 and 1910 [2] and were often labour intensive, needed long analysis times and had a low time resolution. Developments in air quality monitoring techniques during the second half of the 20th century enabled higher data quality to be obtained, with lower detection limits, using automated, continuous methods. Today, measurements of particles can vary widely, even those made for the same material and in the same place. This variation is mainly caused by the equipment used for measuring particles and the sampling procedures.

According to their dimensions, the particles suspended in the atmosphere are classified as:

- *primary particles*, generated during the combustion process, that are directly emitted into the atmosphere and are composed of fine particles, with diameter less than 2.5 µm (PM2.5), and by ultrafine particles, with diameters smaller than 0.1 µm (PM0.1) [3].
- *secondary particles*, generated by mechanical or chemical reactions in the atmosphere, that ae composed of coarse particles with diameters greater than 2.5 µm and smaller than 10 µm (PM10) and total Suspended Particle Matter (TSP) [4].

However, a complete particle characterization involves study of particle morphology as well as chemical characterization.

An overview of instruments available on the market for measurement of particulate matter [5] reveals that practically one deals basically with two categories:

- *instruments and methods of measuring concentration*, using gravimetric, optical (light scattering, light absorption, light extinction), and microbalance methods,

and respectively

- *instruments and methods of measuring size distribution*, such as microscopes, impactors, diffusion batteries (EDB), mobility analyzers, Centrifugal Particle Mass Analyzer (CPMA), Differential Mobility Spectrometers (DMS), Fast Integrated Mobility Spetrometer (FIMS), Electrical Low Pressure Impactor (ELPI), Aerodinamic sizers, etc., based on specific behavior of particles (diffusion, aerodynamics, and optical and electrical mobility) [6].

Choosing the most suitable equipment for PM measurement implies a well balanced analysis of a wide range of characteristics: ability to sample particles in real time; need to dilute gas flow before collection; detection limit of the equipment; size range; accuracy of the equipment, durability, maintenance requirement, and the availability to measure the particle in humidified air stream or in the humidified environment. For example, ELPI and DMS are the suitable devices for measuring fine particles, and the ELPI works in real time; In health-related studies, an EDB is the type of equipment that best characterizes the surface of ultrafine particles.

On the other hand, developments in online air quality monitoring enabled the development of public warning systems and immediate notifications if alert thresholds were exceeded, so that short-term measures could then be taken to reduce emissions during pollution episodes. Such reactive measures are now common place in new legislation [7,8], along with public information to help vulnerable people to cope with pollution episodes [1].

2. Air quality monitoring today and recent progress

In the EU, the current air quality monitoring strategy is mainly driven by the need to achieve and to complywith limit values. Consequently, monitoring sites are predominantly installed where exceedances of limits are likely to occur. In brief, the concept is based on the measurement of PM2.5 at urban background stations [1]. The average PM2.5 concentration of selected urban background sites in a given country over a period of 3 years forms the so-called Average Exposure Indicator (AEI) [9]. This AEI should not exceed a limit value of 20 mg/m^3 by 2015, and should be reduced by a percentage (depending on the initial PM2.5 concentration) by 2020. Recent progress in two aspects of monitoring technologies now makes this possible [1]:

a. Developments in air quality monitoring techniques, such as

- small, low-cost, outdoor-installable or portable devices/sensors with low power consumption,
- automated multicomponent analysers,
- analysers for new particle metrics (e.g. black carbon, particle number or surface area).

b. Developments in data retrieval and analysis, e.g.

- for the determination of the spatial variability of air pollutants on urban scales based on data from multiple low-cost sensors and geographic information systems (GIS),
- integrated data systems allowing real-time interactions between pollution monitoring, public information and pollution reduction measures.

3. Recommendations for the future

Looking forward, the recent developments in monitoring techniques, data retrieval and analysis offer the possibility for regulatory monitoring to move beyond the approach based on fixed monitoring sites [10]. The two main components of this developement process are [1]:

a. Integration of air quality data from diverse sources

Future air quality monitoring should combine all available "monitoring" activities and maximise the advantages of each to improve population exposure assessment. The main activities are:

- Fixed sites: Deliver high quality and time resolved data, but at the cost of less detailed spatial information.
- Mobile and flexible installations: Allow the collection of highly spatially and temporally resolved data using small, low consumption monitoring devices.
- Modelling: Enables the calculation of the spatial and temporal variation of air pollutants in urban areas at all locations, but often with relatively high uncertainty.
- Combination of local and regional air quality information: Facilitates the assessment of regional scale and transboundary contributions to exposure levels.
- Remote sensing, including satellites: Observation of air pollutants over a wide area, but lacking height resolution that would allow for direct use in exposure/health related air quality monitoring.

In the short to medium term, the current focus of air quality monitoring in Europe needs to continue on the basis of fixed monitoring sites, while in the long term, the increased use of urbanscale modelling linked to fewer fixed monitoring sites and a network of mobile, flexible monitors supplemented by remote monitoring, should be explored. Validated model results would allow the higher data quality obtained from measurements to be linked to the better spatial information obtained from modelling and would also allow comprehensive scenario testing to develop better abatement strategies, improvements in public information and the visualisation of air pollution exposure. However, a key role of fixed measurement networks in future should be to provide high quality data to underpin sensor and model based assessments. Substantial gains may be realised through the future systematic development and integration of these measurement and assessment techniques into a single homogeneous information network, minimising the risks of pitfalls, and maximising the benefits of each information source, to produce a high quality spatially- and temporally-resolved data set in near real time.

b. Integration of air quality monitoring and research through an overarching strategy

The challenges of managing urban air pollution have evolved substantially in the last decades and will continue to evolve in the future due to changes in the causal factors and as a consequence of new scientific insights. However, delays of many years can occur before the outputs from new research are taken up and subsequently used by policy makers. To counter this lag, research and monitoring should be strongly integrated through a strategy so that the large investments are explicitly geared to addressing research questions effectively, alongside the assessment of limit value compliance and the population exposure. One way this could be accomplished is to create dedicated areas for research and monitoring of air quality (ARMAQs), in carefully selected urban agglomerations, to facilitate research into such things as:

- new monitoring devices for fixed or mobile measurement locations, for both new and existing metrics,

- new data collection, analysis and visualisation tools,
- improved exposure assessments for population-based health effect studies,
- the development and testing of alternative air quality indicators for urban air quality and health.

Future monitoring strategies should therefore include the collection and assimilation of health effects data, along with air quality data, which should also include new pollutants and alternative metrics. This would allow direct and rapid assessment of the success of air pollution abatement measures, and would greatly improve the detection of relationships and trends in air pollution health impacts. An extension to other environmental stressors can be envisaged which would further enhance our knowledge on environmental and health issues. ARMAQs with integrated health monitoring and epidemiologic research could be used to develop and evaluate pilot-test strategies for health effects-oriented air quality monitoring.

The current review of the European air quality policy (launched in 2011), upcoming research under Horizon 2020 as well as the next revision of the European air quality directive foreseen for 2018 will be an excellent framework to further develop European air quality legislation and regulation, taking climate change issues into account, and so to improve the environment, human health, and the quality of life in Europe [1].

References

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