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Critical Literature Review

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Current air quality plans in Europe designed to support air quality management policies

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ABSTRACT

The intensification of the human activity in urban areas as a result of the increasing population has contributed to the air pollution worsening in cities. To reverse this trend, the European Commission established a legal framework to improve the air quality. Thereby the Member States need to develop air quality plans (AQP) for zones and agglomerations where air quality limit values are exceeded, in order to implement pollution control strategies and meet the legal requirements. Understanding the reasons for the levels of air quality non–compliance as well as evaluating available and commonly used tools to predict the air quality and their effects, is crucial for the decision–making process on air quality management policies. Based on a compilation of regional and local AQP, a review of assessment capabilities and used modeling tools to evaluate the effects of emission abatement measures on the air quality and health was performed. In most cases, models are applied to estimate emissions and to assess the resulting air quality from both reference and emission abatement scenarios. Air quality´s impacts on the health and environment are rarely quantified. Regarding the air quality assessment, beyond the modeling, monitored data for validation of simulations are also used. Some studies, however, do not include the use of air quality models, considering the monitoring network as spatially representative of the study domain (e.g. Lisbon Region, Riga, Malta). In order to overcome methodological limitations for quantifying the impacts of emission abatement measures, economic evaluation techniques or even Integrated Assessment Methodologies (IAM) have been developed. IAM, already applied in some AQP or case studies, namely for Antwerp and London, are used for assessing how reductions in emissions contribute to improve air quality, reduce exposure and protect human health.

Keywords: *Air quality plans, urban air quality, European legislation, modeling tools, integrated assessment methodologies*

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1. Introduction

Nowadays, poor air quality is recognized as one of the most pressing problems in urban areas with very harmful impacts on the health and environment (EEA, 2013). Moreover, the World Health Organization has recently classified air pollution as carcinogenic to human beings (WHO, 2013). According to the latest report on air quality in Europe (EEA, 2013), air pollution implications are mainly due to high levels of particulate matter (PM) and ozone (O_3) in the atmosphere. Anthropogenic emissions are identified as the greatest contributors to the concentration levels of air pollutants, but atmospheric phenomena occurring at different spatial scales also contribute to the increase of environmental damages.

In order to reduce air pollution effects, particularly in cities where the majority of the European population lives, it is important to define effective planning strategies for air quality improvement. For this purpose, Air Quality Plans (AQP) establishing emission abatement measures, previously known as Plans and Programs, have to be designed and implemented by the Member States (MS) of the European Union (EU) in accordance to the Framework Directive 96/62/EC on ambient air quality assessment and management. In 2008, based on the Framework Directive and in other previously existing legal documents, a new Air Quality Directive (AQD) (EC, 2008) was published, introducing new concepts, and simplified and reorganized guidelines. The application of numerical models is highlighted in this new Directive as a fundamental tool to better assess and manage air quality, encouraging their use in the preparation of AQP. These models must be used in combination with monitoring in a range of applications, since observed values are crucial for validation of these modeling approaches.

In most European MS the modeling tools used in AQP consider processes directly influencing the air quality, from the emission to dispersion and deposition of air pollutants, but do not include, for example, exposure or indicators related to health. Methodologies combining the effects of several emission abatement measures on the air quality and potential impacts on human health, as well as the economic evaluation associated to the implementation of measures and resulting external costs, enable cost–benefit/ effectiveness analyses of the control options (Amann et al., 2011) and are an added value to the decision–making process. For this reason, in the recent years, Integrated Assessment Methodologies (IAM) have been receiving prominence in the scientific literature (e.g. D'Elia et al., 2009; Carnevale et al., 2012). Nevertheless, the multi–scale and multi–pollutant analysis of the measures effect is seen as one of the most research challenges in order to decrease the uncertainties associated with the modeling.

The main objective of this study is to present a comprehensive literature review of existing assessment capabilities and modeling tools used by MS to evaluate the effects of local and regional AQP on the reduction of atmospheric pollutant concentrations and on human health. Limitations of the currently available assessment methods as well as the identification of best–practices for quantifying the overall impact of the measures are also addressed.

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This review is mainly based on the analysis of AQP developed by MS, but there are two main initiatives/publications that have to be specifically mentioned: the assessment report on plans and programs reported under the Directive 1996/62/EC (Nagl et al., 2007), which is mainly focused on the emission abatement measures adopted by the Member States; and the FP7 project APPRAISAL (Air Pollution Policies foR Assessment of Integrated Strategies At regional and Local scales).

The paper is organized in the following sections: (a) overall structure of an AQP; (b) characterization of the reviewed AQP in terms of addressed air pollutants and used methodologies for assessing air quality and their effects taking into account the proposed emission abatement measures; (c) identification of the current methodological limitations and best–practices for quantifying the overall impact of the measures.

2. Overall Structure of an Air Quality Plan

The formulation and implementation of an AQP for improving air quality in polluted areas (e.g. zones or agglomerations), where air quality limit values are exceeded, should imply the characterization of emission sources, the assessment of the contribution of these sources to the ambient concentration levels, and the prioritizing of the sources that need to be tackled. According to the Directive 2008/50/EC (EC, 2008), zone is defined as a part of the territory of a MS, delimited by that MS for the purposes of air quality assessment and management. Agglomeration corresponds to a zone that exceeds 250 000 inhabitants, or with a given population density per km^2 to be established by the MS.

The integrated assessment of the various improvement options, namely emission abatement measures, in relation to their economic and technical feasibility and to their effects on the environment and human health should also be properly considered. Moreover, it is important to ensure that the air quality standards are achieved within the specified time frame in the AQP. Figure 1 illustrates the different components that have to be included in an AQP. Note that contributions from natural sources are not considered as an exceedance, as established in the Directive 2008/50/EC (EC, 2008).

To identify the emitting sources as well as to assess their individual contribution to the air pollutants concentration, source apportionment techniques are often conducted. This implies a previous knowledge of the atmospheric concentrations, measured or modeled at the receptor. The adoption of these techniques also allows understanding the maximum feasible air quality improvement that can be achieved by reducing emissions from those sources, due to the application of emission reduction policies for protection of the human health and environment (Air4EU, 2006; Borge et al., 2014).

Atmospheric emission inventories (AEI) must be as detailed and specific as possible, aiming to contribute to a more correct characterization of the reference situation. Accordingly, at the urban scale, bottom–up approaches should preferably be used instead of top–down emission inventories. However due to data compilation difficulties, it is a current practice to use disaggregation methods from a more comprehensive emissions inventory.

Meteorological conditions and chemical boundary conditions are also important components to consider in air quality modeling. A comprehensive set of meteorological conditions should be selected, since the meteorology influences the dispersion and the chemistry of the atmospheric pollutants and contributes to variations in polluted air arriving to a region from other regions and/or countries.

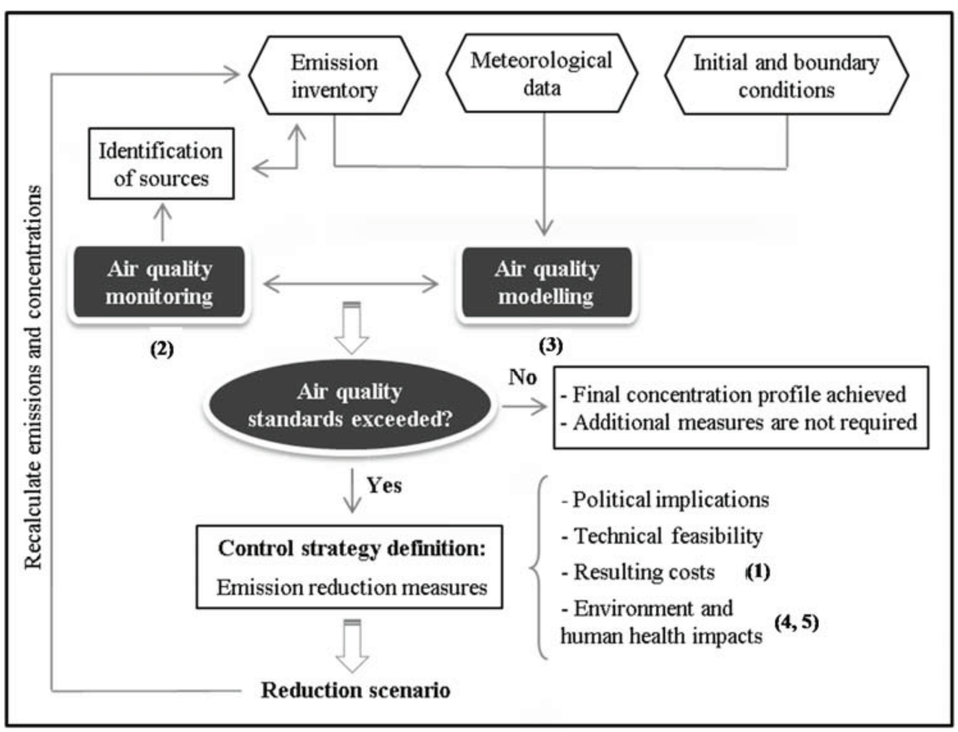

Figure 1. *Simplified scheme of the different stages to be included in an AQP. The components numbered in Figure 1 are related to the distinct aspects covered by the reviewed AQP, as referred in Table 1.*

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