Air Pollution

Assessment Methodology and Modeling

Edited by
Erich Weber

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PREFACE

The North Atlantic Treaty Organization (NATO) established the "Committee on the Challenges of Modern Society" (CCMS) at the November 1969 meeting of the North Atlantic Council.

The CCMS was charged with developing meaningful environmental and social programs that complement other international programs, and with showing leadership, first, in solution of existing problems and, second, in development of long-range goals for environmental protection in the NATO sphere of influence and in other countries as well. A first Pilot Study on Air Pollution was initiated by the CCMS at its inaugural meeting in December 1969. The United States (Environmental Protection Agency) has been the pilot nation with the Federal Republic of Germany (Federal Ministry of the Interior) and Turkey (Scientific and Technical Research Council) as co-pilot nations.

The Pilot Study on Air Pollution was an action program designed to demonstrate and encourage the utilization of existing knowledge for the development of air quality management programs. It entailed the demonstration of a systems approach to air quality management. Case studies have been carried out in Ankara, Turkey; Frankfurt, Federal Republic of Germany; St. Louis, U.S.; Oslo, Norway; and South Holland Region, The Netherlands (NATO/CCMS Report No. 6, Appendices A - E).

The results of the pilot study are documented in NATO/CCMS Report No. 6 (Revised) "Guidelines to Assessment of Air Quality" of October 1972 and in NATO/CCMS Report No. 33 (Final Report) containing 15 recommendations as well as in several other documents, listed as Appendix II.

Starting from the recommendations, the Federal Republic of Germany proposed to initiate a new Pilot Study on Air Pollution Assessment Methodology and Modeling at the CCMS Plenary Session on October 22 and 23, 1974.

In Spring 1975 the North Atlantic Council approved the German proposal. The pilot study work started with the Federal Re-

public of Germany (Federal Ministry of the Interior) as pilot nation and the United States of America (Environmental Protection Agency) and Belgium (Service du Premier Ministre) as co-pilot nations. A Working Group and two Panels were established with the following functions:

Working Group

- Act as a steering committee for the pilot study and develop a strategy for coordinating the work of the two expert panels.
- Assist in the preparation of the reports and final recommendations to the CCMS and review the documents prepared by the panels.

Assessment Methodology Panel

- Develop techniques for emission inventories and emissions projecting.
- Continue to review present and future assessment studies with respect to the application of assessment methodology.

Modeling Panel

- Develop standardized models for various air quality management applications.
- Develop programs to improve modeler/user communications in conjunction with the Assessment Methodology Panel and the Working Group.

The Editor and chairman of the Working Group wishes to acknowledge the scientists participating from pilot, co-pilot, and observer countries, and many other persons, who assisted in the preparation of this document.

The names and addresses of all working group, panel, and ad-hoc group members are listed in Appendix I.

Full recognition is given to each member for carrying out and coordinating review and other activities related to the development of the documents in his respective country. The Editor wishes to express his warmest thanks to Mrs. C. Morawa and to R.D. Baumann, B. Gutsche, W. Klug, L. Kropp, H. Meinl, F. Nieuwstadt, T. Schneider, and J. Tikvart for their contributions and assistance.

INTRODUCTION

Today protection and enhancement of the environment in which man lives is an important and widely recognized objective. Nevertheless, the implementation of a long-term environmental policy has not become easy. This policy and all its consequences is beset by conflicting interests and opposition. Particularly the possiblity of economic recession has increased the sensitivity of nations to environmental policy measures.

It is of decisive importance from the outset for environmental policy that possible future risks must be taken into account as early as now. Thus we must not stop with a description of the present state and the present economic situation. But we must proceed further to give a well-founded forecast of future developments. Therefore, environmental policy needs coordination of economic and other aspects to ensure overall societal stability.

Air pollution has existed for many centuries. However, man's activities now attack the natural fresh air so severely that a pollution control which aims at abatement in several areas of the globe is necessary to prevent a threat to human health, animals, plants and ecosystems. Because of inter-regional and long-range atmospheric transport, many national and international monitoring programs have been implemented.

Efforts have been made in many countries to reduce emissions of specific pollutants from selected source categories. But because of growing industrialization, population and prosperity the quantity and type of air pollution has increased globally.

The results of the NATO/CCMS pilot study on air pollution assessment methodology and modeling can be summarized as follows:

Air Quality Management Systems

Although efforts are being made to reduce emissions from particular sources, additional and co-ordinated activities are

urgently needed. It is not sufficient to control air pollution by means of isolated actions, control actions have to be integrated into a co-ordinated system. For this reason, a small group of members from the working group of the NATO/CCMS pilot study has prepared a report on Guidelines to Air Quality Management Systems (Chapter 1).

The guideline is addressed to national, regional and local authorities concerned with the establishment and operation of an air quality management system. It gives an overview of several systems, it describes their building blocks as well as the technical and economical requirements and their legal and administrative implications as related to ambient air quality standards and control strategies.

An air quality management system (AQMS) consists of the following items:

- an assessment of present ambient air quality, the pollution emission and related factors
- the comparison of existing air quality levels with standards, criteria and guidelines
- the projection of future emissions and ambient air quality
- the development, implementation and revision of a control strategy.

The AQMS comprises the past history, the present situation and future developments of air quality in the region concerned. In the AQMS the assembled information is used to develop a strategy plan, this plan is implemented, the results are analysed and if necessary, revised after the incorporation of future information.

The AQMS aims to obtain and maintain an acceptable level of ambient air quality. Although emphasis is mostly placed upon human health effects, it includes effects on flora and fauna and the interaction with other environmental media, to obtain a total environmental approach.

The assessment part includes source and emissions inventories, the determination of existing ambient air quality and related factors such as meteorological and atmospheric chemistry data.

Most AQMS are based on emission standards, product standards, or air quality standards or on a combination of two stand-

ards or all of them. In the guideline emission standards and the related control technology, equipment standards and product standards are discussed together with air quality standards or objectives.

The economic aspects of an air quality management system are discussed in relation to ambient air monitoring costs, the costs of emission inventories and the costs of modeling.

The strategy plan is the final and most difficult part of an AQMS. Generally speaking, the selection of the initial strategy plan should be based on:

- determination of ambient air quality
- determination of the sources of air pollutants
- modeling and projection of air pollution emissions to forecast future air quality
- formulation, implementation and enforcement of air pollution control.

The strategy plan must be reviewed periodically and revised as appropriate. A revision is necessary if the plan is inadequate to obtain the ambient air quality standards or objectives. Also a review of the plan should be made after periods of 3 - 5 years. These reviews will check whether assumptions and boundary conditions applied in the plan design are still valid.

The emphasis in the guideline is put on the formulation and selection of a strategy plan. Therefore major strategy plan options and criteria for the selection of a control strategy for the surveillance technique are described in detail. Also, three documents on air pollution emissions inventory systems (Chapter 6), air pollution emissions projecting (Chapter 7) and introduction to air quality modeling (Chapter 2) produced by the two panels of the CCMS air pollution study are added to form an integral part of the report on Guidelines to Air Quality Management Systems.

Air Quality Modeling

The Modeling Panel has worked on the development and application of multiple source air quality models. Information has been gathered which describes the performance of multiple source Gaussian air quality models used in several NATO countries. The Modeling Panel has brought together the model developers and the air quality managers to consider and evaluate the application of given models to specific problems in the various member nations.

The Modeling Panel has been responsible for the development of the following documents:

1. Introduction to Air Quality Modeling

2. Uses and Needs for Air Quality Modeling

3. Fundamentals for the Application of a Gaussian Plume Model

4. Practical Demonstration of Multiple Source Urban Air Quality Modeling

5. Bibliography of Grey Literature on Applied Air Quality Modeling

6. Bibliography of Grey Literature on New Modeling Techniques

7. Proceedings of the 6th, 7th, 8th, 9th and 10th International Technical Meetings on Air Pollution Modeling and Its Application.

The first document (Chapter 2) introduces the aims of air quality models, i.e. the fundamental problem of calculating pollutant concentrations in the environment due to one or several emitting sources. This document reviews methods used and problems encountered when modeling air pollution.

The document on uses and needs for air quality modeling (Chapter 3) intends to document the status and current uses of air quality simulation models, problems encountered in their application and the requirement for the models.

The document on fundamentals of the application of a Gaussian plume model (Chapter 4) shall give information on the capabilities, applicability and limitations of one special model to calculate air quality, the Gaussian plume model.

The paper on the practical demonstration of multiple source urban air quality models (Chapter 5) summarizes the characteristics of the models involved in this comparative examination and the results of the model calculations.

Two documents on grey literature (not included in this book) intend to give a summary of literature on applied (mainly Gaussian plume) models and new models in form of a bibliography. They shall help the modeler or user to trace literature on several subjects of modeling via descriptors.

As a result of these publications and through active participation in the International Technical Meetings on Air Pollution Modeling

and Its Applications, the Modeling Panel has been successful in promoting a common NATO basis for dealing with air quality management problems using common modeling techniques. Evidence of the success of these efforts has been presented in all of the International Technical Meetings.

Assessment Methodology

The Assessment Panel members have exchanged their views and experiences in the fields of emissions inventory systems and emissions projecting. Two documents have emerged as a result of these exchanges.

The first document on air pollution emissions inventory systems (Chapter 6) consists of an introductory part and a number of technical papers. In the technical papers the emissions inventory systems, as used or as being developed in the NATO countries, are described. From these papers it is obvious that large differences exist in the objectives and resources of the different inventory systems and, as a consequence, also large differences in the effectiveness of these systems. Some countries have extensive inventory systems, while others are only in the process of developing a system or have limited their objectives to inventorying a specific pollutant or to a limited area of the country.

The most significant results of the panel's work are presented in the introductory part of the chapter. It summarises the objectives of an inventory, and shows how the scope of the inventory is determined. It describes which elements the system may contain, the resolution that can be obtained, how the data can be collected, and processed, and how they should flow through the system.

Perhaps most useful for the reader is the checklist for establishing an emissions inventory system. In this section a number of important suggestions are offered concerning the planning and the concept of the system, as well as about the collection, handling and updating of the data.

The chapter as a whole will be extremely useful to someone who is faced with the task of setting up, organizing and operating either a large or a small system.

The second document on air pollution emissions projecting (Chapter 7) is concerned with projecting emissions, an activity that is of utmost importance in the framework of an air quality management system. Since this field is relatively new, only two countries (USA and Germany) have already had experience in emissions projecting. In this chapter the reasons for and the capabilities of estimating future emissions are discussed. A number

of valuable techniques to be used in macro- and micro-forecasting are offered. After a discussion of responsibilities, the uncertainties of forecasting emissions are also discussed. It appears that for applying the projection techniques to the available emissions inventory data bases, primarily area source data must be forecasted, and individual emitters are only represented by a few aggregated categories in the forecast. The following types of information are required: census and economic data, regulations, control technology, emission factors and local data. Also the form and the content of the forecasts, the validation of the methodologies and the required resources are briefly mentioned.

Glossary of Terms

The compilation of a Glossary of Terms (Chapter 9) was not planned initially. But when the first drafts of the national contributions to air pollution emission inventory and the document about the practical demonstration of multiple source urban air quality models were written, the panel members noticed that varying English terms for expressing certain subjects were in use in the different cooperating countries. Sometimes, discussions about technical and scientific items among the experts ended when it was realized that language differences, and not basic scientific divergences, were the reason for the discussion.

In particular, the present glossary lists and explains terms which are contained in the documents of the air pollution pilot study. They are used in the air quality management system document as well as in all assessment methodology and modeling documents. The explanations were partially taken from already existing glossaries - they are quoted on one of the first pages of the document - and partially they were worked out by the panel members.

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Volume 1 AIR POLLUTION MODELING AND ITS APPLICATION I
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Edited by Erich Weber

CONTENTS