REVIEW

AMBIENT AIR QUALITY PROGRAMMES FOR HEALTH IMPACT ASSESSMENT IN THE WHO EUROPEAN REGION

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An important aim of air quality assessment is to provide information about population exposure and health impact assessment. Numerous epidemiological studies have already shown that exposure to excessive levels of ambient air pollutants are associated with either acute or chronic health effects. Until recently, the adequacy of monitoring population exposure in relation to quantitative assessment of health effects of air pollution was rarely considered in ambient air monitoring strategies. This made the formulation of health-related recommendations to risk management difficult and weakens preventive and other measures to reduce adverse health effects of air pollution. To improve local and national capacities for health impact assessment, the European Centre for Environment and Health of the World Health Organization has prepared methodology guidelines concerning selected aspects of air monitoring. The WHO Collaborating Centre for Air Quality Management and Air Pollution Control support efforts in line with international programmes on quality assurance and control for Europe.

Key words:
ambient air quality monitoring, exposure assessment, quality assurance and control

Population growth of cities does not stop (1). The World Health Organization (WHO) predicts that by the year 2025 about 59% of the world population will live in urban agglomerations. Already today, a considerable proportion of the European population lives in areas where air pollution concentration reaches levels of health relevance. The latest WHO estimates on air pollution health impact presented at the Third European Ministerial Conference on Environment and Health in London on 16–18 June 1999 indicate that ambient air pollution accounts for 3–4% of premature mortality and

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disability in Eastern Europe and causes at least half a million deaths worldwide per year [WHO Press Release 32, 15 June 1999]. The reduction of risks to health is the main objective of pollution abatement strategies undertaken by authorities of various levels and promoted by most of the society. This is also one of the targets of the new pan-European health policy framework (2). Among the elements required for the design of effective pollution abatement strategy is an identification of basic characteristics of pollution causing the most serious or most prevalent health problems in the exposed populations.

The design of pollution abatement strategy aimed at effective protection of population health requires more than the knowledge of locations where the adverse health effects may occur. Information on the severity and magnitude of the effects, in terms of the type and expected number of cases attributable to the pollution, may be necessary to justify and support decisions which may be costly and will require various efforts from the society. Health benefits expected from the pollution abatement may overweight these costs and the programmes may easier gain public support. The quantitative estimates of the outcomes provide »health impact assessment« methodology. It requires information on population exposure to the pollutants of health relevance as well as knowledge of exposure-health associations established on the basis of epidemiological and toxicological studies.

The evaluation of air quality is important for assessing the nature of population exposure to air pollution. Reliable data are an indispensable condition for any further assessment or measure. The WHO recommends a harmonisation of international environmental data, such as ambient air quality data, and therefore quality assurance and control (QA/QC) activities are highly desirable. This demand becomes more and more evident after the recent political changes in the WHO European Region which now counts 51 Member States.

This article introduces a general approach to health impact assessment of air pollution and describes current actions. A recently completed WHO European project pays special attention to the development and improvement of strategies for health-related ambient air monitoring. Because reliable health impact assessment needs sound quality of measurement data, the paper also gives examples of current quality assurance and control activities in ambient air monitoring.

HEALTH IMPACT ASSESSMENT OF AIR POLLUTION

Human exposure to air pollution may result in a variety of health effects depending on the type of a pollutant, magnitude, duration, and frequency of exposure, and the associated toxicity of the pollutant of concern. Exposure to air pollutants occurs both outdoors and indoors, depending on the activities of individuals. It is important to assess the exposure levels of different population sub-groups, especially of sensitive or susceptible individuals such as children, elderly, and the infirm. Health impact assessment combines estimates of population exposure with toxicity or exposure-response information. Exposure- or dose-response relationship information is quite relevant for estimating potential health risks. Health impact estimates for a population-base are calculated typically in terms of number of predicted excess health outcomes (e.g. increase in hospital admissions or acute mortality) due to exposure to certain levels of air pollution. This involves multiplying the concentration-response function by number of people exposed to each concentration level in the community.

Over the last decade, there have been major advances in our knowledge and understanding of air pollution health effects. Today, health impact assessment is being more and more developed as a (routine) tool in decision making for air quality control and public health action aimed at air pollution risk reduction, and its results should be regularly reported to those who need to know. As the most appropriate way to evaluate air pollution health effects in the general population, valid estimates from epidemiological studies are essential elements of health impact assessment.

The WHO European Centre for Environment and Health (WHO/ECEH, Bilthoven Division, The Netherlands) periodically reviews health risks related to air pollution in the WHO European Region in order to identify the most exposed populations and to indicate the pollution sources of health relevance. To implement this task, WHO/ECEH works on the development of air quality assessment methodology, evaluates the evidence on links between health and exposure to air pollutants, and collects information on the population exposure to air pollution for the database HEGIS (Health and Geographic Information System). WHO/ECEH has recently developed a software tool (AirQ) designed to assess health impact and to send air quality data to HEGIS.

National public health institutions have similar tasks in the Member States, and the international evaluation of air quality is a well-established activity of the European Environmental Agency (EEA, Copenhagen, Denmark). There is a need to harmonise the work and to find the most effective ways for the national and international organisations to collaborate. Recently, WHO/ECEH, EEA and the European Topic Centre for Air Quality (ETC-AQ, Bilthoven, The Netherlands) jointly proposed a comprehensive programme of air pollution health impact assessment in Europe for the years 2000 and 2001.

Evaluation of population exposure to air pollution is not always sufficiently well addressed by the air quality monitoring systems. Spatial variability of the pollution concentration and the differences between the areas covered by the monitoring and the places where population is located make the use of air quality data generated by routine monitoring networks problematic. Also the method of routine reporting of air quality monitoring data sometimes limits their usefulness of the collected information for exposure assessment and for evaluation of health impacts of air pollution.

The main purpose of routine ambient air monitoring is the control of the compliance of air quality with guidelines or national standards. Until recently, the adequacy of monitoring of population exposure in relation to the quantitative assessment of health effects of air pollution was rarely considered in the ambient air monitoring strategy. This made difficult the formulation of health-related recommendations to the risk management and limited the effectiveness of preventive measures or reduction of adverse health impacts of the air pollution. The new EU directives an air quality provide a good step forward.

To foster exposure-based monitoring, the WHO Regional Office for Europe (WHO/EURO, Copenhagen, Denmark) established programmes on ambient air quality monitoring for health impact assessment. To improve local and national capacities for health impact assessment WHO/ECEH has prepared a project on »Strategies for Health-Related Ambient Air Monitoring« which provides methodology guidelines concerning selected aspects of ambient air quality monitoring (3).

STRATEGIES FOR HEALTH-RELATED AMBIENT AIR MONITORING

Recognising the importance of valid information on population exposure to air pollutants, in 1998 WHO/ECEH completed this project which defines features of monitoring networks allowing their use in assessing potential exposure of population to ambient air pollution. The air quality assessment must include links with population exposure as well as links with the pollution sources. The scope of the project was determined by a preparatory group meeting. More than twenty international experts from Europe and North America contributed to the project as participants of the working group and as authors.

The report is not intended to serve as a detailed manual of monitoring practice and methodologies. The target groups of the publication are network managers (those who undertake design of new or modify existing networks), policy makers at various administrative levels, and persons who influence policy. As the emphasis of the monograph is on strategic issues and general approaches, the reader is referred to other existing publications for more technical details of the methodology discussed.

The monograph focuses on local pollution with due consideration of the contribution of long range transport of air pollutants. It also includes considerations about harmonisation between local networks in order to obtain a national picture. While it is well recognised that indoor sources of air pollution contribute to the total exposure of individuals and populations to air pollution, this project concentrates on monitoring pollution in the outdoor air. This is justified by differences between monitoring exposure to indoor air pollution and ambient air quality assessment, as well as by a specific need to provide tools for management of health risks related to ambient air pollution. This is also the reason why links of ambient air quality with the pollution sources are discussed.

The first part of the monograph recounts activities of WHO such as the monitoring programme Global Environmental Monitoring System (GEMS-Air) and its successor Air Management Information System (AMIS), as well as activities related to methodology of air pollution health impact assessment. The principles stated in this project should allow progressive modification of the air quality monitoring networks improving their usefulness for health impact assessment. The methods discussed are relevant for the components considered by the revised and updated WHO Air Quality Guidelines for Europe (4). Since the set of monitored pollutants depends on the specific situation in the investigated city, the project specifies methods for selection of components in a given situation. It also considers actions of the European Commission on the new Framework Directive and Daughter Directives for air quality monitoring.

The second part focuses on the role of air quality in the causal chain between the pollution emission and health effects. Presented and discussed examples accompany theoretical aspects of model calculations such as those for air quality dispersion, statistical models, and health impact analysis.

The third part formulates general concepts of air quality assessment, including principles of monitoring network design and operation, quality assurance and control problems, data interpretation, and reporting.

Part four describes specific approaches to monitoring of selected air pollutants (CO, O_3, SO_2, NO_2, PM_{10} and $PM_{2.5}$, benzene, PAH (BaP), Pb, and Cd) to illustrate the principles listed in part three.

The monograph closes with a number of important conclusions and recommendations for each step of air quality monitoring. Specific details of these issues are discussed in the body of this monograph and in references cited in it (3).

QUALITY ASSURANCE AND CONTROL IN AMBIENT AIR MONITORING

For several years efforts have been strengthened in the process of harmonising ambient air quality measurements in Europe. Quality Assurance and Control activities are partly in practice at the national and international level. European actions are supported and conducted, for example by the Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe of the United Nation Economic Commission for Europe (UNECE-EMEP) co-ordinated by the Norwegian Institute for Air Research (NILU, Kjeller, Norway), and for the European Commission by the European Reference Laboratory for Air Pollution of the Joint Research Centre for the Member States of the European Union (JRC/ERLAP, Ispra, Italy).

In line with these actions the WHO Collaborating Centre for Air Quality Management and Air Pollution Control (WHO CC) at the (former Institute for Water, Soil and Air Hygiene of the) German Federal Environmental Agency (UBA) –, Berlin, Germany supports QA/QC efforts focusing on Member States of the WHO European Region. Such activities are the basis for comparison and compatibility of air quality data of country networks all over Europe in order to manage environmental risks to health and to assess the impact of air pollution on health. Follow two examples of current WHO CC activities on QA/QC.

Intercomparison measurement Workshops

Sample system design and maintenance, regular site visits, audits, and intercalibrations have an important role in network quality assurance. As an example, intercomparison workshops compare ambient air quality measurement methods of a common sample at one central laboratory facility. Continuing the series of intercomparisons on Air Quality Monitoring in the WHO European Region (5–7), the WHO CC conducted two workshops in May 1999. The main objective of this activity is to serve as a QA/QC platform supporting especially those countries which are not routinely involved in other programmes. The workshops address laboratories which are responsible for QA/QC in air quality monitoring networks, either at the national, regional, or local level. The intercomparison measurements took place at the national reference laboratory for air quality of the German Federal Environmental Agency (UBA Pilotstation) in Langen, Germany. The common testgas sample were suitable for automated, semiautomated, and/or manual devices. Each participating laboratory achieved *in situ* calibration of its analyser(s) using the national calibration method (reference or transfer standard). The workshop programme was harmonised with the intercomparison programme of the European Commission, conducted by the JRC/ERLAP for EU Member States in April 1999 in Ispra, Italy. The 1999 WHO CC workshops focused on sulphur dioxide, oxides of nitrogen, ozone, and benzene. Whereas the overall objective of intercomparisons is to assist and help laboratories to check, compare, and improve the quality of their measurements, the specific aims of the 1999 campaign were:

– to compare all measurement systems of participating teams during measuring test periods for day and night and for each test gas under laboratory conditions;
– to compare daytime and nighttime measurements in the ambient air;
– to audit the calibration standards (e.g. national reference standards) of participating laboratories with the UBA primary standard calibration; and
– to exchange acquired experiences in operating and managing the measurement and calibration systems.

Altogether thirteen laboratories of environmental (nine) and health (four) institutions participated at both workshops in May 1999. The laboratories were from Budapest (Hungary), Langen (Germany), Ljubljana (Slovenia), two from Prague (Czech Republic), Riga (Latvia), Sofia (Bulgaria), St. Petersburg (Russia), Tallinn (Estonia), Tashkent (Uzbekistan), Tirana (Albania), Vilnius (Lithuania), and Zagreb (Croatia). Both automatic analysers (eight monitors) and manual methods (five methods of sampling followed by wet chemical analysis) were used during the intercomparison measurements. Detailed technical description of measuring methods, devices, and calibration procedures, as well as the evaluation and interpretation of all intercomparison results are pending publication in the WHO CC series Air Hygiene Report in 2000 (8).

Such intercomparisons can only record a momentary measuring situation under laboratory conditions. None of the manual or automated measurement methods could, however, claim to measure the »true« value. The standard deviation and a tolerance range of ±10% from the target value are used as a landmark for interpretation and evaluation of intercomparison results. Nevertheless, the programme of WHO CC intercomparison measurement workshops are to be seen as an important step in QA/QC that is to provide, by automatic and manual methods of measurement, reliable data for environmental health impact assessment.

Status Report on Quality Assurance and Control

Before using air quality data for health impact assessment one has to be certain of their reliability. This is why one needs information on QA/QC activities in air quality monitoring networks of the WHO European Member States. In connection to the 1999 intercomparison workshops, WHO CC carried out a survey of QA/QC activities in Central and Eastern European networks. A special questionnaire was designed to obtain a comprehensive overview of comparable and compatible information on QA/QC of national laboratories which participated in the intercomparisons.

The required information concern the network design, such as number of monitoring sites, location specifications, and the variety of measured air pollutants. It also requires information about regular QA/QC system operations, on-site functions, audits, calibrations/intercalibrations, and training courses. In order to maximise data integrity, further quality control measures are necessary. The final part of the questionnaire is focused on data management and reporting. All information of this compilation will be evaluated and published in a status report of the WHO CC series Air Hygiene Report in 2000 (9).

The WHO Regional Office for Europe highly recommends that the experiences gained during these QA/QC activities should become part of ambient air quality monitoring networks at the national, regional, and local levels in the Region.

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Sažetak

PROGRAM PRAĆENJA KAKVOĆE VANJSKOG ZRAKA SVJETSKE ZDRAVSTVENE ORGANIZACIJE U EUROPSKOJ REGIJI RADI OCJENE UČINKA NA ZDRAVLJE

Važan cilj ocjene kakvoće zraka je dobivanje informacije potrebne za ocjenu izloženosti stanovnika i utjecaja na zdravlje. Izloženost ljudi onečišćenju zraka može imati za posljedicu različite zdravstvene učinke, ovisno o vrsti onečišćenja, razini, trajanju i učestalosti izloženosti i toksičnosti neke onečišćujuće tvari. Mnoge epidemiološke studije već su pokazale da je izloženost povišenim razinama raznih onečišćujućih tvari u vanjskom zraku povezana s akutnim ili kroničnim zdravstvenim učincima. S obzirom na to da je u Europi u toku više takvih projekata, potrebno je uskladiti njihov rad i pronaći najučinkovitije načine suradnje nacionalnih i međunarodnih organizacija. U strategiji praćenja onečišćenja vanjskog zraka rijetko se razmatra prikladnost praćenja izloženosti stanovnika u odnosu na kvantitativnu ocjenu zdravstvenih učinaka onečišćenja zraka. To otežava formulaciju preporuka pri suzbijanju rizika, sprječavanja ili smanjenja štetnih zdravstvenih učinaka onečišćenja zraka. Da bi se unaprijedile lokalne i nacionalne mogućnosti za ocjenu zdravstvenih učinaka, Europski centar za okoliš i zdravlje Svjetske zdravstvene organizacije (SZO) pripremio je smjernice za metodologiju odabranih gledišta praćenja kakvoće zraka. Usklađivanje mjerenja kakvoće vanjskog zraka bitno je zbog usporedivosti i sukladnosti podataka o kakvoći zraka. Štoviše, to je osnova da bi se mogla provesti ocjena opasnosti onečišćenja zraka za zdravlje. Tijekom više godina Suradni centar SZO-a za upravljanje kakvoćom zraka i nadzor nad onečišćenjem zraka podupire napore koji se čine u skladu s međunarodnim programima za osiguranje i nadzor nad kakvoćom u Europskoj regiji SZO-a.

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