Health effects of ambient PM—an update

More research is needed to manage air quality effectively for PM.

INTRODUCTION

Directive 1999/30/EC was adopted in April of this year by the Council of the European Union. This is the first Daughter Directive established under the Air Quality Framework Directive. The Directive specifies limit values for a series of pollutants in ambient air, including particulate matter. The limit value for particulate matter is set for particles smaller than 10 micrometers in diameter or so-called PM_{10}. Stage 1 limit values are set at 40 and 50 microgrammes per cubic metre ($\mu g/m^3$) as annual and daily averages respectively, to be achieved in 2005. A maximum of 35 exceedances is allowed annually. A further possible Stage 2 reduction of the annual average to 20 $\mu g/m^3$ and reduction of the number of exceedances from 35 to 7 from 2010 onwards is also indicated, pending a review in 2003. The Directive also requires Member States to start measuring particles smaller than 2.5 micrometers or so-called $PM_{2.5}$, as this may in future be considered an even more relevant measurement for harmful particulate air pollution. At present, however, there are insufficient monitoring data available for use in health evaluations.

The current understanding of the health effects of particulate air pollution was discussed in past editions of the CONCAWE *Review* (e.g. Vol. 6, No. 1 and Vol. 7, No. 1). At that time, a Working Group of experts and the European Commission were developing a position paper that formed the basis for the Commission proposal for the limit values.

Data on current ambient levels of PM_{10} in Europe are not widely available because of the different parameters and measurement methodologies employed by the Member States. In fact, most of the European cities that participated in the APHEA project (cf. CONCAWE report 99/54 and CONCAWE *Review* Vol. 6, No. 1) reported some form of ambient PM monitoring, but none reported PM_{10}. It is commonly accepted that today's levels are lower than in the past, primarily as a result of the decline in the use of coal for heating and power generation.

CONCAWE believes there are many important questions still to be answered that could help determine the real potential for the new Directive to deliver increased health protection. These questions relate to:

- the lack of measured data and the limited accuracy of the methods used to estimate personal exposure, which ultimately determines the potential for health effects;
- the relative importance of ambient PM to an individual's overall exposure in view of other determining factors such as time spent in indoor environments, and PM originating from personal activities including smoking; and
- the need for mechanistic studies to validate the apparent associations between ambient PM and adverse health effects that are demonstrated by environmental epidemiology studies.

EPIDEMIOLOGICAL STUDIES AS INDICATORS FOR HAZARD

Messages in the media about thousands of people dying from exposure to particles (fine dust, PM_{10}, $PM_{2.5}$ etc.) in ambient air must give the impression that fine particles are public health enemy number one.

The current indications for possible adverse health effects are based on a relatively large number of short-term epidemiological studies which relate episodes of increased air pollution to increases in mortality (all causes, respiratory and cardiovascular). On average an increase of 10 $\mu g/m^3$ of PM_{10} would be associated with an increase of 0.4–0.7 per cent in mortality per period of increased air pollution.

Morbidity increases are also studied, with the numbers of hospital admissions for respiratory and cardiovascular conditions being used as indicators.

There are a few long-term studies which relate PM_{10} air concentrations to increased mortality by comparing populations in more polluted with less polluted cities or locations. On average, the results would indicate an increase in annual mortality of ± 5 per cent for each long-term increase in PM_{10} by 10 $\mu g/m^3$.

VALIDITY OF ASSOCIATIONS IS UNCERTAIN

It is uncertain that the associations between exposure to PM_{10} and adverse health effects, including mortality, are true and valid associations:

- there is no information about the personal exposure of the morbidity and mortality cases; exposure misclassification is therefore probable;
- it is unlikely that is has been possible to discriminate between the adverse health effects caused by particles and those caused by other air pollutants which can cause similar effects (ozone, SO_2, NO_2 and CO), and/or other factors such as changes in temperature and humidity, or social class. In other words, sufficient control of compounding factors is dubious.

It is highly probable that bias of exposure misclassification and lack of sufficient control of compounding factors have occurred in the short-term and long-term studies. Therefore, the associations are likely to be invalid as there is no certainty about the true identity of the elements from which the associations are constituted.

CAUSE-EFFECT RELATIONSHIP OF ASSOCIATIONS IS UNCERTAIN

In the 1960s Sir Lawrence Bradford Hill published nine criteria which have been proven to be of help if one wants to get an insight into the probability that an observed true and valid association is based on a direct cause-effect relationship and not just on coincidence or on a remote and indirect cause. These criteria have been applied in CONCAWE report 95/62 and it is clear that there is insufficient evidence for a cause-effect relationship. A similar analysis of both the short-term and long-term studies was published by Dr John Gamble (EBSI) in the prestigious journal *Environmental Health Perspectives* (August and September issues, 1998) and led to the same conclusion.

TOXICOLOGY STUDIES

Ambient airborne particulate matter is generally of unknown and variable composition. There is no agreed scientific explanation of the health effects of PM. It is unknown whether the total amount inhaled is what counts (i.e. mass inhaled), or the chemical composition (the effect of metals content has been investigated), the size (very small, so-called nano-particles, which are smaller than 0.1 micrometer, or fine particles, e.g. $PM_{2.5}$ or PM_{10}, i.e. particles smaller than 2.5 or 10 micrometers, respectively) or even other parameters such as acidity of the particles. Several experimental toxicology studies have reported big differences in toxicity between nano-particles

and fine particles of the same chemical composition, making size the dominant parameter, although the materials studied were not representative of ambient PM.

PERSONAL EXPOSURE STUDIES

Scientists active in the PM field have recognized that the lack of comprehensive studies of personal exposure to PM is a major shortcoming in the present risk assessment for ambient PM, and have started to address this with experimental work. In particular, investigation reports are now starting to appear on how well personal exposures in a community can be estimated from the limited information gained from a single stationary outdoor air monitoring point. Some researchers conclude that the estimates are valid and, hence, further epidemiological studies may use this easily available information instead of having to put a major effort into generating detailed and individual exposure data. CONCAWE experts are reviewing these reports and have so far concluded that outdoor measurements are generally not representative for the measured personal exposures. It is obvious that more work is needed in this area to understand how well or how poorly personal exposure is estimated from limited outdoor measurements.

CONCAWE RESEARCH STRATEGY

Following the logical sequence of the key steps in risk assessment (i.e. hazard identification, exposure assessment, risk characterization and recommendations for risk management), CONCAWE's Management Groups for Air Quality, Automotive Emissions and Health have developed a research strategy which identifies the need for additional research in these areas and which indicates specific areas of interest for CONCAWE. Several actions have already been taken (see box below: CONCAWE reports), other projects are progressing or being discussed.

The intention is to use the results of the research work and desk studies, carried out or sponsored by CONCAWE, in the discussion during the 2003 review, and also as contributions to the workshops that will be held in preparation for the review. Key areas for CONCAWE are: source apportionment, fuel characteristics and particle emissions, health hazard identification, personal exposure assessment and risk characterization.

CONCAWE reports on particulate matter

92/51	The chemical composition of diesel particulate emissions
95/62	Air quality standard for particulate matter
96/56	The measurement of the size range and number distribution of airborne particles related to automotive sources—a literature study
96/61	Review and critique of the APHEA project
99/55	Polycyclic aromatic hydrocarbons in automotive exhaust emissions and fuels
99/54	Overview and critique of the air pollution and health: a European approach (APHEA) project

CONCAWE *Review* articles on particulate matter

Vol. 2, No. 1, April 1993	The influence of diesel fuel characteristics on emissions. Fuel density, sulphur content and cetane number affect the particulate emissions of diesel fuels
Vol. 6, No. 1, April 1997	An introduction to particulate matter issues. Particulate matter: sources and presence in air. APHEA—a pan European study on the effect of air pollution. Analysis of reported data
Vol. 7, No. 1, April 1998	Automotive particulate matter. From mass to number—an exploration into the unknown