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Pollution Control-2020: URBAN AIR POLLUTION IN MEGACITIES OF THE WORLD

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Abstract—Urban air pollution is a major environmental problem in the developing countries of the world. WHO and UNEP created an air pollution monitoring network as part of the Global Environment Monitoring System. This network now covers over 50 cities in 35 developing and developed countries throughout the world. The analyses of the data reported by the network over the past 15—20 yr indicate that the lessons of the prior experiences in the developed countries (U.S.A., U.K.) have not been learned. A study of air pollution in 20 of the 24 megacities of the world (over 10 million people by year 2000) shows that ambient air pollution concentrations are at levels where serious health effects are reported. The expected rise of population in the next century, mainly in the developing countries with a lack of capital for air pollution control, means that there is a great potential that conditions will worsen in many more cities that will reach megacity status. This paper maps the potential for air pollution that cities will experience in the future unless control strategies are developed and implemented during the next several decades.

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INTRODUCTION

The 1972 UN Conference on the Environment in Stockholm called for a concerted attack on all global environmental pollution problems. The United Nations Environment Programme (UNEP) was created, and in partnership with the World Health Organization (WHO) began to address the problems of urban air pollution which were exemplified by the 1952 London Fog in which over 3000 people died (Ministry of Health, 1954). In 1974, UNEP and WHO collaborated in the initiation of a Global Environment Monitoring System (GEMS) urban air pollution monitoring network (GEMS/Air). This network has provided air monitoring equipment to developing countries and has collected air quality data in over 50 cities in 35 countries throughout the world. The initial network focused on sulfur dioxide (SO). suspended particulate matter (SPM) by the high-volume sampler method (TSP), and lead (Pb) analyses of the TSP filters, as these pollutants were identified as the most important for developing countries.

To provide the necessary guidance to GEMS/Air participants, some of which were initiating air monitoring for the first time, WHO and UNEP issued a series of documents that covered the major topic areas, as follows:

u **WHO** (1976) gave **specific** guidance on the monitoring methods to be used for SO and SPM, quality assurance and data reporting;

u WHO (1977) gave guidance on station siting and local network design;

u WHO (1980) gave guidance on analysis and interpretation of ambient air quality data; and

u **WHO** (1982) gave guidance on how to estimate human exposure to air pollution with respect to indoor/outdoor relations and **activity** patterns.

The results of these programmes have been very useful in documenting the extent of the global air pollution problem and have been used by UNEP and WHO to set continuing programme priorities. In 1991 (WHO, 1992) WHO and UNEP developed a plan to expand the network by shifting from TSP data to a measure of size fractionated SPM less than 10 km in aerodynamic diameter and including the collection of air quality data on the air pollutants CO, NO and 3.

While the subject of protection of the atmosphere was very high on the agenda of the recently concluded 1992 UN Conference on Environment and Development at Rio de Janeiro, the topic of urban air pollution was not singled out for special attention. Although references to urban air pollution were made in the Conference report for the next century, **"Agenda-21",** it did not figure as prominently as it should have. Urban air pollution could in the rather near future become, if it already is not, a public health and environmental problem of crisis proportion. Although air pollution is only one of the environmental hazards alongside water contamination, hazardous wastes, etc., it is currently the most politically controversial environmental concern of large cities. It affects every resident, it is seen by **every resident,** and is caused by nearly evety resident.

Of foremost concern is the health and well-being of urban residents. The concentrations of ambient air pollutants, which **prevail** in **many** urban areas, are sufficiently high to cause increased mortality, morbidity, deficits in pulmonary function and cardiovascular and neurobehavioural **effects (WHO,** 1987; **Schwartz** and Dockery, 1992; Dockery *et aI.,* 1993). Indoor sources of air pollution, such as cooking fires and **tobacco smoking, contribute** toward general human exposure and can result in even more severe exposures for **people** in their homes (Smith ci at., 1994). In addition to health, there are other concerns. Air pollution **is seriously damaging material resources of** the cities, **such as** buildings and **various works of** art. Its impact on vegetation is also of concern. Finally, urban **agglomerations** or "supercities" **are also** major sources of regional and global atmospheric pollution and certain greenhouse gases.

In order to assess the problems of urban air pollution in a global context, the WHO and UNEP initiated a detailed study of air quality in 20 of the 24 megacities of the world **(WHO/UNEP,** 1992). For the purposes of this study, megacities were defined as urban agglomerations with current or projected populations of 10 million or more by the year 2000 as shown in Fig. 1 (UN, 1989). The four megacities not chosen for inclusion in the study were Osaka (because of similarity to Tokyo) and Tehran, Lagos and Dacca because of a lack of data upon which to perform the study. The urban areas chosen included cities in all parts of the world—two in North America, four in Central and South America, one in Africa, 11 in Asia and two in Europe. The megacities are not necessarily the world's most polluted cities. The primary reasons for singling out the megacities are that they already have serious air pollution problems; they encompass large land areas and many people (the total population of the 20 megacities in 1990 was estimated to be 234 million); and many other cities are heading for megacity status. In 2000, the United Nations estimate that there will be 59 "supercities" having over five million population and many of these will reach megacity status in the next century (UN, 1989). This last point is of particular importance. A review of the air pollution situation in the present-day megacities and identification of their difficulties in finding solutions can serve as a warning to the problems facing rapidly growing urban areas, and act as a guide to solving and preventing some of them. Preventing pollution problems before they can occur is often the most cost-effective approach.

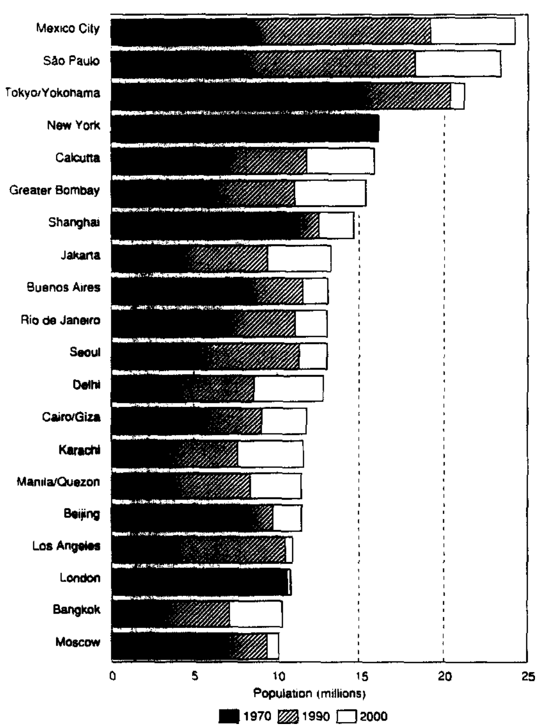

Fig. 1. Estimated population of 20 mcgacities in 1970 and **1990** and projected population in 2030 (Source: UN, **1989).**

RESULTS

The megacity study (WHO/UNEP, 1992) was carried out within the framework of the WHO/UNEP GEbIS/Air Programme. The GEMSJAir data were supplemented by other air quality data, information on sources and emissions of air pollutants, and other factors of importance in evaluating air pollution that are referenced within **WHO/UNEP** (1992). Such data and information were supplied by national and municipal authorities directly to **WHO/UNEP** secretariats or obtained through WHO/UNEP staff, consultant missions, and in some instances from the scientific literature. The draft assessments were reviewed by a WHO/UNEP Government-Designated Expert Group meeting on Urban Air Pollution Monitoring which was convened in Geneva in **1991.** Some of the principal findings and conclusions of the study are presented here WHO/PEP, 1992).

The first observation is that air pollution is widespread across the megacities and is often most severe in cities in developing countries. But even in the others, health norms are being exceeded, although to a lesser degree. Each of the 20 **megacities** has at least one major air pollutant which occurs at levels that exceed **WHO** health protection guidelines **(WHO,** 1987) as shown in Fig. 2; 14 of these megacities have

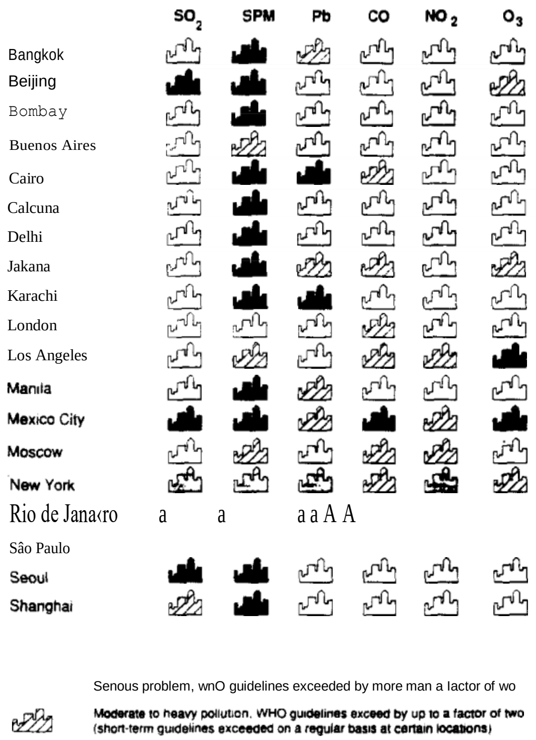

Fig. 2. Overview of air quality in 20 megacities based on a subjective assessment of monitoring data and emissions inventories.

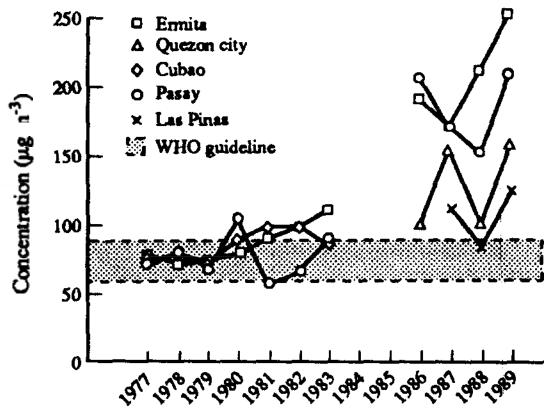

Fig. 3. Annual mean suspended particulate matter concentrations in Metropolitan Manila.

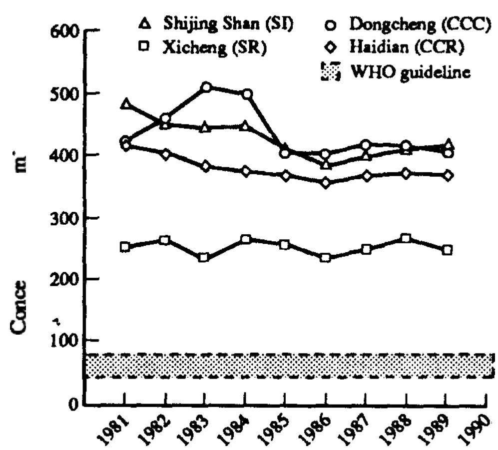

Fig. 4. Annual mean suspended particulate matter (TSP) concentrations in Metropolitan Beijing.

two such pollutants and seven have three or more. The last group consists of Beijing, Cairo, Jakarta, Los Angeles, Mexico City, Moscow and Sao Paulo. Five of these seven are located in the Pacific Basin. They are facing a variety of air pollution problems requiring comprehensive solutions. In the majority of the megacities, air quality is getting worse as the population, traffic, industrialization and energy use are increasing and there is much urgency in instituting control and preventive measures. Figure 3 shows the change in SPM (TSP) in Manila, going from air quality within the WHO guidelines in 1977 to an exceedance by a factor of two or more by 1989.

In degree of severity, the high levels of SPM are the major problem affecting the megacities as a group. SPM presents a very serious problem in 12 of the megacities surveyed, the majority of which are located in the Pacific Basin. The concentrations of SPM in these cities are persistently above the WHO guidelines (WHO, 1987) by a factor as much as two or three (Fig. 2). Figure 4 shows that SPM (TSP) in Beijing has an annual average of order **400 pg** m ' which is well above the WHO guideline. Recent U.S. studies show mortality correlations with SPM at much lower levels of SPM (Schwartz and Dockery, 1992; Dockery ci *al.,* 1993). Therefore, there is a concern that more serious SPM-related mortality is likely to exist at similar SPM levels in developing countries where the delivery of medical care in acute cases is not as proficient **(WHO,** 1995).

In the second grou another five megacities—the health guidelines are also exceeded but by a lesser margin. There are only three megacities in which SPM is by-and-large within WHO prescribed limits, albeit within the range of SPM where Buctuations in mortality have been associated with fluctuations in ambient SPM (Dockery *et al.,* 1993). Ambient SPM of anthropogenic origln is emitted into the urban air by a whole host of sources and activities, or it is produced by photochemical processes that lead to the presence of fine aerosols less than 2.5 pm in aerodynamic diameter. The most notable emission processes are combustion of fossil fuels for power generation in industry and for heating purposes. This anthropogenic SPM is much more toxic than the SPM of natural origin (Beck and Brain, 1982). Motor vehicles, certain industrial processes, and burning of waste also produce and emit particulates. High levels of natural wind-blown SPM, albeit less toxic than man-made particles, are another feature which complicates this particular air pollution problem. The proximity to desert areas or barren lands leads to high natural loadings of crustal particulates in cities like Beijing, Cairo, Delhi, Karachi, Los Angeles, and Mexico City. Even if this crustal SPM is relatively inert, its presence in the lung potentiates the toxicity of the anthropogenic particles because it increases the residence time of the more toxic SPM (WHO, 1995).

Air-borne lead (Pb) is an important air pollutant where leaded petrol for motor vehicles is still sold. In high concentrations it is known to impair liver and kidney functions and is associated with reduced mental development of infants and children (WHO, 1987). Although Pb is emitted by vehicles as small particles, they can agglomerate into large particles that are re-entrained by wind and traffic. For the cities surveyed, there are still some where high levels of Pb are recorded. They include Cairo and Karachi and, to a lesser extent, Bangkok, Jakarta, Manila and Mexico City. In all others, Pb levels appear to be within WHO guidelines, and in many of them Pb in petrol has been either totally eliminated or greatly reduced.

One of the positive developments observed is that coal and high sulfur oil have been or are being replaced by cleaner fuels such as natural gas which contains less ash and less sulfur (WHO, 1988). At present, the principal fuel in the 20 megacities is split almost equally among coal, oil and natural gas. Coal, however, is still the predominant fuel for industry and energy in Beijing, Calcutta, Delhi, Seoul and Shanghai. Along with this changeover have come reductions in air pollution levels, particularly sulfur dioxide and the upward trend in ambient concentrations has been reversed in a number of cities. In addition to the cities in the developed countries where vast reductions in S 2 concentrations were achieved 15 or 20 yr ago, a downward trend is evident in Bangkok, Bombay, Calcutta, Manila, Sao Paulo and Seoul (Fig. 5).

Of very special concern for health is the use of coal or biomass fuels for home heating and cooking purposes (Smith *et al.*, **1994).** Due to the highly inefficient combustion and the fact that these emissions are released a metre or two above the ground level within residential districts, the exposures to people can be extremely high. While the use of these fuels for domestic purposes is being phased out in many urban centres, large areas of Beijing, Calcutta, Dacca, Delhi, **Shanghai** and Seoul—among the megacities—still experience this type of pollution with the attendant adverse effects on health. The open burning of refuse is also still a common occurrence in some of the megacities with consequent high air pollution concentrations in the vicinity.

Motor vehicle traffic is a major source of air pollution in the megacities. In half of them it is the single most important source. It is a major source of four of the six major air pollutants—CO, NO,, HC and

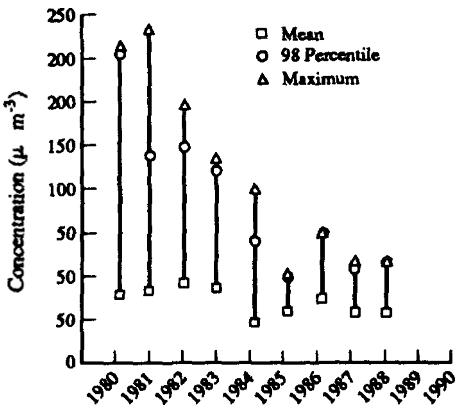

Fig. S. Annual mean, 98 percentile and annual maximum sulphur dioxide concentrations at the GEMS site in Bangkok.

Pb-and contributes to the SPM concentration. Since 1950, the global vehicle fleet has grown tenfold and is estimated to double from the present total of 630 million vehicles within the next 20-30 yr **(WHO/** ECOTOX, 1992). Much of the expected growth in vehicle numbers is likely to occur in developing countries and in eastern Europe.

As cities expand into megacities, more people will drive more vehicles greater distances and for longer times. In the absence of controls, the automotive emissions will likewise increase. In Bangkok, for example, it is estimated that they will double by the year 2000 (WHO/ECOTOX, 1992). In cities where a substantial portion of the motor vehicle fleet is diesel-powered there are additional problems of black smoke and greater particulate emissions. Such a situation exists in Bangkok, Manila and Seoul. The implementation of automotive emission controls in the cities is paramount given the already high concentrations of automotive-related air pollutants, the rapid increase in motor vehicle traffic and the long time it takes for controls to take effect.

Indeed, many of these cities need to supplement technological automotive emission controls with administrative controls to reduce the vehicle kilometres travelled, such as better public transport systems. Several supercities have already begun using "incentive" approaches to securing improved air quality, especially indirect-based incentive policies. Gasoline taxes are a good example of such approaches.

From a review of trends in air quality in different cities it is quite evident that "history repeats itself". The experience of the current megacities in the developed countries is being repeated in the developing countries. As shown in Fig. 6, before rapid industrial development takes place, air pollution is mainly from domestic sources and light industry; concentrations are generally low and increase slowly as population increases. As industrial development and *per capita* energy use increase, air pollution levels begin to rise rapidly (WHO, 1988). Then urban air pollution

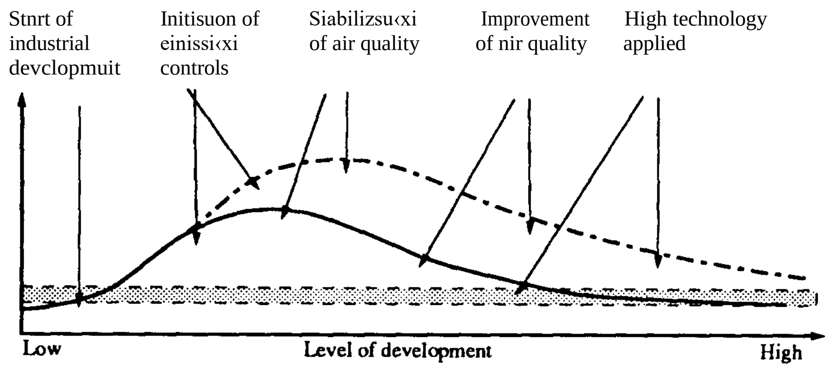

Fig. 6. Development of air pollution problems in cities according to developmentstatus.

becomes a serious public health concern and emission controls are introduced. Owing to the complexity of the situation, an immediate improvement in air quality cannot generally be achieved; at best the situation is stabilized, and serious air pollution persists for some time.

Several of the megacities studied are now in the situation where additional controls must be implemented without delay. Experience has shown that the introduction of emission controls has been followed by a staged reduction of air pollution as controls take effect. The earlier that integrated, enforceable air quality management plans are put into effect, the lower the maximum pollution levels that will occur. This is especially important for those cities of developing countries that are not yet of the size and complexity of present-day megacities.

One of the major findings of our study was the gross insufficiency in air quality information in the megacities. While some of the megacities have comprehensive monitoring and evaluation systems, there were many where the air quality systems are rudimentary at best. In general, the capabilities of cities fall into four categories as follows.

In the first category, megacities such as Los Angeles, Mexico City, New York, Osaka, Sao Paulo, Seoul and Tokyo maintain comprehensive air quality monitoring networks that provide realtime data on all major air pollutants. These networks incorporate adequate quality control procedures to ensure that the data are demonstrably valid.

In the second category are cities with mostly marginal to adequate air monitoring networks which measure only a few pollutants and usually at fewer sites than desirable. Included in this group are cities such as Bangkok, Beijing, Bombay, Calcutta, Delhi, London and Rio de Janeiro.

The third category are the megacities with inadequate air monitoring capabilities which produce data of unknown quality on a few pollutants. They include such cities as Buenos Aires, Cairo, Karachi, Manila, Moscow and Tehran. Air quality monitoring capabilities must be improved in many of these megacities.

The fourth category consists of the megacities (and future megacities of the next century) with virtually no air monitoring capabilities. Dacca and Lagos had no air quality data available to WHO/UNEP for this study. It is evident that the development of an infrastructure for air quality monitoring and management (quality assurance, repair and maintenance of instruments, etc.) is a necessary condition that must be fulfilled before air quality monitors can be operated in such cities and generate reliable data.

CONCLUS1ONS

WHO/UNEP (1992) made several recommendations for developing countries to follow to address the problems of urbanization and air pollution:

(1) Air quality management should be implemented as a matter of urgency in those cities where strategic planning is weak or non-existent. Such efforts are needed in well over half of the megacities studied.

(2) More attention should be given to short-term, realistic approaches to begin to reduce some of the air pollution. Steps which can be taken include energy conservation, institution of motor vehicle inspection programmes and phasing out of Pb in petrol. Promotion of the use of mass transit and finding alternatives to open burning of refuse provide some other possibilities for reducing air pollution in the near term.

(3) In the longer term, preventive measures must be incorporated in new industrial and urban developments. Proper urban and transportation planning can achieve significant improvements in air quality. The introduction of clean technologies is a major goal in air pollution management.

In conclusion, there is an immediate need to improve the monitoring and emissions inventory capabilities in cities. These are prerequisites for sound air pollution management strategies with the main aim of protecting public health.

Acknowledgement—This paper is based upon the findings of the WHO/UNEP study of urban air quality in megacities carried out as part of the Global Environment Monitoring System, an element of the United Nations Earthwatch programme. The authors represent the major organizations and units that carried out the study, and acknowledge with thanks hundreds of scientists world-wide, who gathered the air quality data sets and supplemental information upon which this study rests.

REFERENCES

Beck B. D. and Brain J. D. (1982) Prediction of the pulmonary toxicity of respirable combustion products from residential wood and coal stoves. In *Residential* ***Wood*** *and Coal* Combustion, pp. 264—280. Air Pollution Control Association, Louisville, Kentucky.

Dockery D. W., Pope C. A. III, Xu X., Spenglet J. D., Ware J. H., Fay M. E., Ferris B. G. Jr. and Speizcr F. E. (1993) An association between air pollution and mortality in six U.S. ciuee. *New* £ngfnnd *J. Med.* **329,** 1753—1759.

Ministry of Health (1954) Mortality and Morbidity during the London Fog of December, 1952. Reports on Public Health and Medical Subjects No. 95, Her Majesty's Stationary Otfice, London.

Schwartz J. and Dockery D. W. (1992) Increased mortality in Philadelphia associated with daily air pollution concentrations. *Amen.* Rev. Aespir. *Disease* l4S, 6tD-604.

Smith K. R., Apte M. G., Ma Y., Wongsekiartitar W. and Kulkarni A. (1994) Air pollution and the energy ladder in Asian cities. £iierpy fiit. J. l9, 587—591.

UN (1989) *Prospects* ***of World*** *Urbanization 1988.* Population Studies No. 112, New York.

UNEP/WHO (1988) *Assessment of Urban* Air l2unfity. United Nations Environment Programme and World Health Organization, Nairobi.

USEPA (1994) The Concise Guide to AIRS AQS (May, 1994). Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

WHO (1977) *Air Monitoring Programme* Desiqn /or *Urban and Industrial* Areas. WHO Offset Publication No. 33, WHO, Geneva.

WHO (1980) *Analysing and Interpreting Air Monitoring* Dntn. WHO Offset Publication No. 51, WHO, Geneva.

WHO (1982) *Estimating* ffumnn Exposure to *Air Pollution.* WHO Offset Publication No. 69, WHO, Geneva.

WHO (1987) Air vitality *Guidelines for Europe.* WHO Regional Publications, European Series No. 23, WHO Regional Ofiice for Europe, Copenhagen.

WHO (1995) Interpretation of WHO Air Quality Guidelines. Report of an Expert Working Group, WHO/EOS/95, Geneva (in press).

WHO/ECOTOX (1992) In 3fotor Vehicle *Air* Pollution—*Public Stealth Impact and Control Measures,* WHO/PEP/92.4 (edited by Mage D. T. and Zali 0.). World Health Organization and ECOTOX, Geneva.

WHO/PEP (1992) Urban Air Pollution Monitoring—Report of a Meeting of UNEP/WHO Government-designated Experts, Geneva, 5-8 November 1991. WHO/PEP/92.2, UNEP/GEMS/92.A.1, World Health Organization, Geneva.

WHO/UNEP (1992) *Urban Air* Pollution *in Megacities of* the l¥orId. World Health Organization, United Nations Environment Ptogramme, Blackwell, Oxford.