APPENDICES

APPENDIX 1

WHO guidelines for assessing and using epidemiological evidence for environmental-health risk assessment

Following the recommendations of the WHO guidelines on the assessment and use of epidemiological evidence for Environmental Health Risk Assessment [1,2], the major steps in the process of HIA are summarised here:

- specify the purpose of the assessment, associating decision-makers, scientists, and stakeholders.
- specify the methods used to quantify uncertainties in each step of quantification where uncertainties come into play and assumptions that have to be made.
- specify exposure. If exposure represents a mixture, the selection of the most reasonable indicator(s) of the mixture has to be discussed. Attention should be paid to the time dimension of exposure (averaging times and duration). The distribution of exposure in the target population and in the epidemiological studies used to derive the exposure-response functions should be coherent. The magnitude of the impact depends on the level and range of exposure for which HIA is required to estimate attributable cases. The choice of a reference level may consider epidemiological and other data with regard to issues such as the existence of thresholds and natural background levels. If exposure in the target population exceed or are below those studied, it will be necessary to determine whether exposure-response functions should be extrapolated or not.
- define the appropriate health outcomes. The purpose of the HIA, the definition of exposure and the availability of the necessary data will guide the selection of outcomes. In some cases, the HIA should be assessed separately for each health outcome for which there is evidence of an effect. In other cases, in particular when estimating the monetary costs, we should avoid overlapping of various health outcomes.
- specify the exposure-response relationship. The exposure-response function is the key contribution of epidemiology to HIA. The function may be reported as a slope of a regression line or as a relative risk for a given change in exposure. Exposure-response functions may be derived from pooled analysis or published meta-analyses.
- derive population baseline frequency measures for the health outcomes under consideration, this is to quantify the prevalence or incidence of the selected outcomes. This information should preferably be obtained from the target population for which HIA is being made.
- calculate the number of attributable cases, under the assumption that exposure causes the health outcome, based on the distribution of the exposure in the target population, the estimates of the epidemiology exposure-response function and the observed baseline frequency of the health outcome in the population. The uncertainties in the data that contribute calculation to the impact assessment, as well as natural sources of heterogeneity in the effect of exposure will often require the calculation of a range of estimates of attributable cases in order to describe fully the likely impact of exposure and better reflect the uncertainty.

Interpreting results of the HIA includes explicit discussion of assumptions and limitations. Sensitivity analyses in which the effects of key assumptions are explored quantitatively, may provide a better sense of the overall uncertainty of the estimates than purely qualitative discussions.

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1. Evaluation and use of epidemiological evidence for Environmental Health Risk Assessment. WHO Regional Office for Europe, Copenhagen 2000 (EUR/00/5020369)
2. Quantification of health effects of exposure to air pollution. WHO, Regional Office for Europe, Copenhagen 2001, (E74256)

Finally, attributable cases are often interpreted as the preventable fraction, meant to be prevented, had exposure been removed. Caution, however, is warranted with such an interpretation. First, the benefit of removal of a particular exposure may only rarely be estimated.

The benefit may be realised much later than or not to the full extend, predicted. In our case, lower air pollution levels would take years to be fully realised. Second, the attributable risk estimation does not take competing risks into account. Removing one risk factor, e.g., air pollution, will increase the relative importance and contribution of other risks and causes of morbidity and mortality. Accordingly, it is well known for multicausal diseases that the sum of attributable cases across several risk factors does not add up to 100% but may be larger.

APPENDIX 2

Exposure – Response (E-R) functions used by Apheis for the HIA

For short-term effects of particles on total mortality, respiratory and cardiovascular hospital admissions, the E-R functions are provided by the APHEA2 study:

Health indicator	PM_{10} RR for 10 µg/m³	PM_{10} 95%CI	Black smoke RR for 10 µg/m³	Black smoke 95%CI
Total mortality All ages ICD9 <800 (1)	1.006	1.004-1.008	1.006	1.003-1.008
Respiratory hospital admissions 65 years + ICD9 460-519 (2)	1.009	1.006-1.013	1.001	1.000-1.009
Cardiac hospital admissions all ages ICD9 410-414.427.428 (3)	1.005	1.002-1.008	1.011	1.004-1.018

For long-term effects of PM_{10}, the E-R functions used come from the HIA in Austria, France and Switzerland[4] based in two American cohort studies.

Health indicator	RR for 10 µg/m³	95%CI
Total mortality 30 years + ICD9 <800	1.043	1.026-1.061

1. Katsouyanni K, Touloumi G, Samoli E, Gryparis A, Le Tertre A, Monopolis Y, Rossi G, Zmirou D, Ballester F, Boumghar A, Anderson HR, Wojtyniak B, Paldy A, Braunstein R, Pekkanen J, Schindler C, Schwartz J. Confounding and effect modification in the short-term effects of ambient particles on total mortality: results from 29 European cities within the APHEA2 project. *Epidemiology.* 2001 Sep.12(5):521-31.

2. Atkinson RW, Anderson HR, Sunyer J, Ayres J, Baccini M, Vonk JM, Boumghar A, Forastiere F, Forsberg B, Touloumi G, Schwartz J, Katsouyanni K. Acute effects of particulate air pollution on respiratory admissions: results from APHEA 2 project. Air Pollution and Health: a European Approach. *Am J Respir Crit Care Med*. 2001 Nov 15; 164(10 Pt 1): 1860-6.

3. Le Tertre A, Medina S, Samoli E, Forsberg B, Michelozzi P, Boumghar A, Vonk J.M, Bellini A, Atkinson R, Ayres J.G, Sunyer J, Schwartz J, Katsouyanni K Short term effects of particulate air pollution on cardiovascular diseases in eight European cities. Accepted in JECH

4. Künzli N, Kaiser R, Medina S et al. Public-health impact of outdoor and traffic-related air pollution: a European assessment. *The Lancet* 2000; 356:795-801

APPENDIX 3

Council Directive 1999/30/EC of 22 April 1999

Relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air

Official Journal L 163, 29/06/1999 P. 0041 - 0060

Article 5

Particulate matter

1. Member States shall take the measures necessary to ensure that concentrations of PM_{10} in ambient air, as assessed in accordance with Article 7, do not exceed the limit values laid down in Section I of Annex III as from the dates specified therein. The margins of tolerance laid down in Section I of Annex III shall apply in accordance with Article 8 of Directive 96/62/EC.

2. Member States shall ensure that measuring stations to supply data on concentrations of $PM_{2.5}$ are installed and operated. Each Member State shall choose the number and the siting of the stations at which $PM_{2.5}$ is to be measured as representative of concentrations of $PM_{2.5}$ within that Member State. Where possible sampling points for $PM_{2.5}$ shall be co-located with sampling points for PM_{10}. Within nine months of the end of each year Member States shall send the Commission the arithmetic mean, the median, the ninety-eighth percentile and the maximum concentration calculated from measurements of $PM_{2.5}$ over any twenty-four hours within that year. The ninety-eighth percentile shall be calculated in accordance with the procedure laid down in Section 4 of Annex I to Council Decision 97/101/EC of 27 January 1997 establishing a reciprocal exchange of information and data from networks and individual stations measuring ambient air pollution within the Member States(6).

3. Action plans for PM_{10} prepared in accordance with Article 8 of Directive 96/62/EC and general strategies for decreasing concentrations of PM_{10} shall also aim to reduce concentrations of $PM_{2.5}$.

4. Where the limit values for PM_{10} laid down in Section I of Annex III are exceeded owing to concentrations of PM_{10} in ambient air due to natural events which result in concentrations significantly in excess of normal background levels from natural sources, Member States shall inform the Commission in accordance with Article 11(1) of Directive 96/62/EC, providing the necessary justification to demonstrate that such exceedances are due to natural events. In such cases, Member States shall be obliged to implement action plans in accordance with Article 8(3) of Directive 96/62/EC only where the limit values laid down in Section I of Annex III are exceeded owing to causes other than natural events.

5. Member States may designate zones or agglomerations within which limit values for PM_{10} as laid down in Section I of Annex III are exceeded owing to concentrations of PM_{10} in ambient air due to the resuspension of particulates following the winter sanding of roads. Member States shall send the Commission lists of any such zones or agglomerations together with information on concentrations and sources of PM_{10} therein. When informing the Commission in accordance with Article 11(1) of Directive 96/62/EC, Member States shall provide the necessary justification to demonstrate that any exceedances are due to such resuspended particulates, and that reasonable measures have been taken to lower the concentrations.

Within such zones or agglomerations Member States shall be obliged to implement action plans in accordance with Article 8(3) of Directive 96/62/EC only where the limit values laid down in Section I of Annex III are exceeded owing to PM_{10} levels other than those caused by winter road sanding.

ANNEX III

LIMIT VALUES FOR PARTICLES (PM_{10})

	Mean period	Limit value	Margin of tolerance	Date on which the limit value must be respected
PHASE I				
1. 24 hours limit value for the human health protection	24 hours	50 µg/m^3 PM_{10} to be not exceeded more than 35 times per year	50% at the date of entering into force of the present directive, with reduction by 1st january 2001, and every 12 months following, by a constant percentage, until reaching 0% at 1st january 2005	1st January 2005
2. Annual limit value for the human health protection	1 year	40 µg/m^3 PM_{10}	20% at the date of entering into force of the present directive, with reduction by 1st january 2001, and every 12 months following, by a constant percentage, until reaching 0% at 1st january 2005	1st January 2005
PHASE II				
1. 24 hours limit value for the human health protection	24 hours	50 µg/m^3 PM_{10} to be not exceeded more than 7 times per year	According to the data; should be equivalent to the limit value of Phase I	1st January 2010
2. Annual limit value for the human health protection	1 year	20 µg/m^3 PM_{10}	50% at the date of 1st january 2005, with reduction every 12 months following, by a constant annual percentage, to reach 0% at 1st january 2010	1st January 2010

APPENDIX 4

Exposure Assessment

Hans-Guido Mücke and Emile De Saeger

In order to harmonise and compare the information relevant to exposure assessment in 26 Apheis cities in 12 countries a questionnaire was prepared by the Exposure Assessment Advisory Group. The following text summarises and interprets the findings of this group.

All twenty six cities completed Appendix 4.

Table A

Table A gives an overview of the results to questions 1 to 13, 15 and 16 in Appendix 4.

Air monitoring stations

Apheis cities reported that PM_{10}/BS/TSP measurements were made at a total of 259 monitoring stations. 127 stations were selected as exposure relevant and appropriate for calculating health impact assessments (HIA).

a) PM_{10}

PM_{10} was measured in 20 cities at 106 monitoring stations. Eighteen cities selected and evaluated 54 stations (51%) as exposure and HIA relevant.

b) Black Smoke (BS)

Fifteen cities measured BS at 125 stations. 61 stations (49%) were assessed as exposure and HIA relevant.

c) Total suspended particulates (TSP)

TSP measurements were made in six cities at 28 stations, whereas only two cities evaluated 12 TSP monitoring stations (43%) as appropriate for HIA.

Altogether 127 PM_{10}/BS/TSP monitoring stations (49%) have to be considered as exposure and HIA relevant. Due to the fact that in six cases PM_{10} and BS were measured in parallel at the same site, 121 stations were finally considered for the HIA evaluation (see table B).

Measurement methods

a) PM_{10}

The applied automatic PM_{10} measurement methods can be distinguished into the ß-ray absorption method (in 4 cities at 12 stations) and the tapered oscillating microbalance method (TEOM, which is applied in 14 cities at 42 stations).

b) BS

Reflectometry is the commonly used measurement method for BS (in 15 cities at 61 stations).

c) TSP

TSP is measured by using ß-ray absorption method in one city, the second city uses the gravimetric method.

Tables B and C

Tables B and C summarise the results of question 14 in Appendix 4, which considered the classification types of exposure relevant air monitoring stations by measured pollutant (PM_{10}, BS or TSP).

Classification of monitoring stations

Table B gives an overview of the classification of a total of 121 exposure and HIA relevant PM_{10}/BS/TSP monitoring stations in the 26 cities.

The evaluation of table B is collated in table C. Due to the fact that for six stations both BS and PM_{10} have been used for the assessment, the total number of exposure relevant monitoring sites in this respect is 127 (100%). In the majority of cases 78 monitoring stations (61%) are classified as urban residential. 16 stations each were classified as commercial or traffic-related (13% each), followed by sub-urban (8%), industrial (3%) and others (2%).

With regard to the requirements of the first Daughter Directive 1999/30/EC it can be concluded that around 80% of the reported air monitoring sites (classified as urban residential, commercial and sub-urban) can be considered as appropriate for HIA.

Interpretation and Conclusion

In the following section, the results of Appendix 4 are compared to and interpreted as a function of the Apheis Guidelines on Exposure Assessment.

Air quality indicators (PM_{10}, BS and TSP)

The measurement interval of 24 hour averages for PM_{10} and BS complies with the given recommendations for all monitoring stations. This occurred for the TSP measurement in two cities, too.

Site selection

Altogether 101 monitoring stations are in accordance with the Apheis site selection criteria. It has to be considered that 20 stations are classified in a way that they actually should be excluded for further HIA calculations (in three cities 16 stations are traffic-related, and four stations in two cities are in the industrial vicinity).

Despite this, the data from these stations should be used for HIA, because there are still some uncertainties in the interpretation of the local classifications used.

Number of stations

The number of reported stations varies broadly from city to city (for PM_{10} from one up to 14, and for BS from one up to eight per city). It might be that in some cases only one or two stations for large cities do not reflect the population exposure correctly, and may underestimate the exposure of the total urban population.

Measurement methods and factors

The PM_{10}/BS/TSP measurement methods were reported completely. Concerning the use of TEOM the answer of the used probe temperature was given in six of 14 cases only. Because the TEOM probe temperature can be changed there might be an unknown uncertainty. Conversion or correction factors were given for calculating PM_{10} from TSP measurements and in three other cases.

Quality assurance and control (QA/QC), and data quality (DQ)

Most cities reported that QA/QC activities are implemented; this is not the case in three cities. One city does not know the answer yet, and one city did not report.

All cities reported that the DQ could be assessed as validated, only for two cities no answer was given.

As an overall conclusion, it can be stated that the Apheis Guidelines on Exposure Assessment are already in use in the centres with different degrees of application. One big challenge of Apheis is the interaction of local and/or national environmental and health authorities. With regard to the broad variety of responsibilities in Europe, the Apheis cities were able to contact the relevant environmental institutions to collate and provide reliable results for the exposure and health impact assessment of PM_{10} and BS.

Appendix 4 - Table A ([1] Total area, [2] Area covered by air network, [3] 4 week days (Monday-Thursday))

City	Area 1 (km^2)	Area 2 (km^2)	Popul. (Mio.)	PM_{10}	BS	TSP	PM_{10} HIA	BS HIA	TSP HIA	Interval	QA/QC	DQ	Method	Factor
Athens	350		3.0		6			2		24 h	yes		reflectometry	
Barcelona	99		1.5		20	2		7		24 h	no	valid.	normalised smoke	
Bilbao	105	105	0.6	2		7	1			cont	no	valid.	ß-radiation absorption	
					9			9		24 h	no	valid.	reflectometry	
Bordeaux	560	283	0.6	7			4			24 h	yes	valid.	TEOM	
					4			4		24 h	yes	valid.	reflectometry	
Bucharest	238	180	2.0			5			4	24 h[3]	yes	valid.	gravimetric	PM_{10} = TSP x 0.6
Budapest	524	524	1.8			8			8	cont.	yes	valid.	ß-ray-operation	PM_{10} = TSP x 0.58
Celje	230	100	0.05	2			1			cont		valid.	TEOM (50°C)	
					1			1		24 h		valid.	reflectometry	
Cracow	320	320	0.7	6			1			24 h	yes	valid.	ß-gauge-monitor	
					12			1		24 h	yes	valid.	reflectometry	
Dublin	113	113	0.5	3						24 h	yes	valid.		
					14			6		24 h	yes	valid.	reflectometry	
Göteborg	282	282	0.5	4			1			cont.	yes	valid.	TEOM (50°C)	1.03 x PM_{10} + 3 $\mu g/m^3$
Le Havre	199	199	0.2		7			6		24 h	yes	valid.	reflectometry	
Lille	612	612	1.1	7			5			cont.	don`t	valid.	TEOM	
					3			2		24 h	know	valid.	reflectometry	
Ljubljana	902	400	0.2	2			2			cont.	yes	valid.	TEOM (50°C)	
					4			3		24 h	yes	valid.	reflectometry	
London	1600	1600	7.2	13			1			cont.	yes	valid.	TEOM	
					8			1		24 h	yes	valid.	reflectometry	
Lyon	500	132	0.8	4		1	2						TEOM	
Madrid	606	606	2.9	25			14			cont.	yes	valid.	TEOM	1.3
Marseille	355	355	0.8	4			3			cont.	yes	valid.	TEOM (50°C)	
					8			2		24 h	yes	valid.	reflectometry	
Paris	762	762	6.2	3			3			hourly	yes	valid.	TEOM	
					10			10			yes	valid.	reflectometry	
Rome	1495	320	2.7	4			4			cont.	yes	valid.	ß-gauge monitor	
Rouen	320	320	0.4		5			5		24 h	yes	valid.	reflectometry	
Seville	141	90	0.5	10			6			cont.	yes	valid.	ß-radiation-attenuation	
Stockholm	500	500	1.2	3			1			cont.	yes	valid.	TEOM (50°C)	1.03 x PM_{10} + 3 $\mu g/m^3$
Strasbourg	304	304	0.5	1			1			cont.	yes	valid.	TEOM (50°C)	
Tel Aviv	171	52	1.1	2			2			cont.	yes	valid.	TEOM	
Toulouse	713	635	0.7	3			2			cont.	yes	valid.	TEOM	
Valencia	100	47	0.7	1		5				24 h	yes	valid.	ß-ray-atomic-absorption	
					14			2		24 h	yes	valid.	reflectometry	
Sum				**104**	**124**	**28**	**53**	**60**	**12**					

[1] *PM_{10} data for Bilbao was not used for the core HIA*

Appendix 4 - Table B

CITY	SITE	CLASSIFICATION	POLLUTANT
ATHENS	Patision	commercial	BS
	Peiraias	commercial	BS
BARCELONA	Llull	residential	BS
	Paris/Urgell	residential	BS
	Pl. Orfila	commercial	BS
	Pl. Palau	commercial	BS
	Pl. Universitat/Balmes	commercial	BS
	Po. Zona Franca	residential	BS
	Sants	commercial	BS
BILBAO	Barakaldo-San Eloy	residential	BS
	Barakaldo-Llano	residential	BS
	Bilbao-Sanidad	residential	BS
	Erandio-Astrabudúa	residential	BS
	Getxo-Las Arenas	residential	BS
	Leioa-Lamiako	residential	BS
	Santurtzi-Ayuntamiento	residential	BS
	Sestao-Plaza	residential	BS
	Sestao-Rivas	residential	BS
	Getxo-Algorta	residential	PM_{10}
BORDEAUX	Grand-Parc	urban/residential	PM_{10}
	Talence	urban/residential	PM_{10}
	Floirac	sub-urban	PM_{10} + BS
	Bassens	sub-urban	PM_{10} + BS
	Place de la victoire	urban residential	BS
	IEEB	urban residential	BS
BUCHAREST	ISPB	residential	TSP
	Policolor	residential/traffic/industrial	TSP
	Sintofarm	residential/traffic/industrial	TSP
	Romaero	residential/traffic	TSP
BUDAPEST	Laborc street	residential	TSP
	Szena square	residential/commercial	TSP
	Déli street	residential/commercial	TSP
	Baross square	residential/commercial	TSP
	Kosztolanyi square	residential/commercial	TSP
	Erzsebet square	residential/commercial	TSP
	Gergely square	residential	TSP
	Ilosvai square	residential	TSP
CELJE	Bolnica	residential	PM_{10} + BS
CRACOW	Kurczaba Str	residential	PM_{10}
	Pradnicka Str	residential	BS
DUBLIN	Royal Dublin Society	sub-urban	BS
	Mountjoy Square	residential	BS
	Clontarf	sub-urban	BS
	Finglas	sub-urban	BS
	Herbert Street	residential	BS
	Bluebell	sub-urban	BS
GOTHENBURG	Femman, Nordstan	commercial	PM_{10}

Appendix 4 - Table B (cont.)

CITY	SITE	CLASSIFICATION	POLLUTANT
LE HAVRE	Ignauval	residential	BS
	Bléville-Maison des Jardins	residential	BS
	Air Normand	residential	BS
	TDF Caucriauville	sub-urban	BS
	Les Neiges	industrial	BS
	Gonfreville l'Orcher	industrial	BS
LILLE	Croix	residential	BS
	Wattrelos	residential	BS
	Marcq-En-Baroeul	residential	PM_{10}
	Lille-Rives	residential	PM_{10}
	Tourcoing	residential	PM_{10}
	Lomme	residential	PM_{10}
	Villeneuve D'Ascq	residential	PM_{10}
LJUBLJANA	HMZ	residential	PM_{10} + BS
	Figovec	commercial/residential	PM_{10} + BS
	Moste	residential	BS
LONDON	Bloomsbury	residential	PM_{10}
	London City	commercial	BS
LYON	Croix Luizet	residential	PM_{10}
	Bossuet	residential	PM_{10}
MADRID	Glorieta Carlos V	traffic	PM_{10}
	Plaza Del Carmen	traffic	PM_{10}
	Marqués De Salamanca	traffic	PM_{10}
	Esquelas Aguirre	traffic	PM_{10}
	Ramón Y Cajal	traffic	PM_{10}
	Plaza De Castilla	traffic	PM_{10}
	Arturo Soria	traffic	PM_{10}
	Villa Verde	traffic	PM_{10}
	Gta. Marqués De Vadillo	traffic	PM_{10}
	Alto Extremadura	traffic	PM_{10}
	Moratalaz	residential	PM_{10}
	Isaac Peral	traffic	PM_{10}
	Alcala	traffic	PM_{10}
	Casa De Campo	others	PM_{10}
MARSEILLE	Saint Louis	residential	PM_{10} + BS
	Cinq Avenues	residential	PM_{10}
	Thiers/Noailles	residential	PM_{10}
	Saint Marguerite	residential	BS
PARIS	Paris 12	residential	PM_{10}
	Bobigny	residential	PM_{10}
	Boulevard périphérique Auteuil	traffic	PM_{10}
	Paris 18	residential	BS
	Paris Tour st Jacques	residential	BS
	Paris 7	residential	BS
	Paris 8	residential	BS
	Paris 14	residential	BS
	Gennevilliers	residential	BS
	Ivry	residential	BS
	Vitry	residential	BS
	Montreuil	residential	BS
	Saint Denis	residential	BS

Appendix 4 - Table B (cont.)

CITY	SITE	CLASSIFICATION	POLLUTANT
ROME	Arenula	traffic	PM_{10}
	Fermi	traffic	PM_{10}
	Magna Grecia	traffic	PM_{10}
	Ada	others	PM_{10}
ROUEN	Val de la Haye-Ecole	industrial	BS
	Petit Couronne	industrial	BS
	Parc Expositions	residential	BS
	Bois Guillaume	sub-urban	BS
	Sotteville	residential	BS
SEVILLE	Ranilla	residential	PM_{10}
	Reina Mercedes	residential	PM_{10}
	Principes	others	PM_{10}
	Enramadilla	residential	PM_{10}
	Macarena	residential	PM_{10}
	Torneo	residential	PM_{10}
STOCKHOLM	Rosenlundsgatan	commercial/residential	PM_{10}
STRASBOURG	Strasbourg Centre	residential	PM_{10}
TEL-AVIV	SL	residential	PM_{10}
	TM	commercial/residential	PM_{10}
TOULOUSE	Lycée Berthelot	residential	PM_{10}
	Rue M. Jaquier	residential	PM_{10}
VALENCIA	Viveros	public garden/residential	BS
	Cruz Cubierta	residential	BS

Appendix 4 - Table C

	Classification types of exposure (HIA) relevant air monitoring stations			
Type	**PM_{10}**	**BS**	**TSP**	**Sum**
Traffic	16	–	–	**16 (13%)**
Kerbside	–	–	–	
Building line	–	–	–	
Commercial	3	8	5	**16 (13%)**
Urban residential	30	41	7	**78 (61%)**
Sub-urban	2	8	–	**10 (8%)**
Rural	–	–	–	
Industrial	–	4	–	**4 (3%)**
Others (e.g. public gardens)	3	–	–	**3 (2%)**
TOTAL	**54**	**61**	**12**	**127 (100%)**

Berlin, Ispra 29.1.2002

H.-Guido Mücke and Emile De Saeger
for the Exposure Assessment Advisory Group

Update of Annex 4

Dear all,

As announced last Saturday, please find enclosed a new version of Appendix 4.

As discussed, due to the heterogeneity of the presented information in Appendix 4, a comparison and are not currently possible for us. The new Appendix 4 form is necessary to get a harmonised compilation in order to compare and interpret the relevant information on exposure assessment for each city.

The requested information for Appendix 4 are in line with the Guideline of the Exposure Assessment Advisory Group.

Your contribution is now kindly requested to support our work of interpretation of the city specific data.

As concluded, please fill in the information in the Appendix 4 form by 8 February 2002 and send it to Sylvia, so that we can work on the interpretation between 11 and 22 February 2002.

Thank you very much for your kind assistance.

Appendix 4 questionnaire

This questionnaire will allow to provide a harmonised compilation of information indicating the exposure relevant area of the city, the number of PM_{10} or BS monitoring sites, and the type, sampling and measurement characteristics of the stations selected for the HIA of Apheis

1. City: ______
2. Agglomeration area of the city (km^2): ______
3. Area (km^2) covered by the air monitoring network in the city: ______
4. Population in this (exposure relevant) area: ______
5. Total number of PM_{10} monitoring stations in this area: ______
6. Total number of BS monitoring stations in this area: ______
7. Total number of TSP monitoring stations in this area: ______
8. Number of selected PM_{10} monitoring stations for HIA: ______
9. Number of selected BS monitoring stations for HIA: ______
10. Number of selected TSP monitoring stations for HIA: ______

Measurement interval (please tick)
continuous ☐ hourly ☐ 24 hours ☐ weekly ☐ 2 weekly ☐

Quality assurance and control (please tick)
yes ☐ no ☐ do not know ☐

Data quality (please cross)
validated data ☐ unvalidated data ☐

14. Name, classification and sampling characteristics of the monitoring site
(kerbside, traffic, commercial, residential, industrial, rural, others)

name *PM_{10}/BS/TSP* *classification*

(for example:
Bismarckplatz *PM_{10}* *residential)*

____

____

____

____

____

____

____

____

____

____

Measurement method

BS: ______________________

TSP: ______________________

PM_{10} manual: ______________________

automated: ______________________

probe temperature (in °C): ______________________

optical: ______________________

Used conversion or correction factor: ______________________

APPENDIX 5

Health data for health impact assesment

Belén Zorrilla and Mercedes Martinez

Mortality data

To estimate the acute effects of air pollution on premature mortality, we have used the daily number of deaths among residents of each city out of the total mortality excluding external causes of death (ICD9 <800; ICD10: chapters I-XVIII).

The information sources for the mortality data are the national, regional or local, mortality registries for all the cities. The year used in each city depends on the availability of the data. Death registration is complete in all of them. The completeness of the data for the basic cause of death was 99% or more in 23 of the 26 cities. One city, Tel Aviv, has 4.6% missing data, and we do not know this percentage for two of the cities (Table 1).

Because we considered all causes of death (excluding external causes of death), erroneous entries or local differences in the selection of cause of death do not affect the comparability of the data.

Hospital admissions data

To estimate the acute effects on hospital admissions, we have selected hospital admissions for residents in each of the cities with discharge diagnosis of respiratory diseases (65 years and older) and cardiac diseases.

For respiratory diseases, the following codes were selected: 460-519 (ICD 9), and the corresponding codes on ICD10: J00-J99.

For cardiac diseases, the codes selected are those corresponding to Ischemic heart diseases (ICD9:410-414; ICD10:I20-I25), cardiac arrhythmias (ICD9 427; ICD10: I47-I49) including cardiac arrest (heart attack) (ICD9 427.5; ICD10:I46) and heart failure (ICD 9: 428; ICD10: I50).

Whenever possible only emergency admissions were selected.

Most of the cities obtain the data from registries, excluding Madrid which uses a survey on a sample of Hospital Discharge orders.

A discharge diagnosis has been used in all cases.

The completeness of the registries is quite high, 100% in most of them. Barcelona and Valencia have a slightly smaller level of completeness. Bordeaux, Lyon, Le Havre, Lille, Marseille, Paris, Rouen, Strasbourg and Toulouse only include public hospitals admissions, so they may underestimate the impact. The completeness of the registers used by Tel Aviv, Bucharest and London is unknown (Table 2).

All the registries, except two, run a quality control programme and completeness in the diagnosis for the cause of admission is quite high, with a percentage of missing data of 1% or lower in 14 of the 18 registries.

The main problem for comparability is the differences in the availability of information in some of the registries. The information sources used in Barcelona, Bilbao, Gothenburg, London, Madrid, Seville, Stockholm and Valencia allow selecting emergency admissions. Yet, for Bordeaux, Bucharest, Celje, Lyon, Le Havre, Lille, Ljubljana, Marseille, Paris, Rome, Rouen, Strasbourg, Tel Aviv and Toulouse, it is not possible to distinguish between emergency and total admissions[1]. This could result in an overestimation of cardiac and respiratory admissions. We do not know the percentage of emergencies out of the total admissions for each city, therefore the comparison between the latter cities and those cities able to select only emergency admissions must be done with care.

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1. According to Hospital admissions in Madrid, around 21% of H.A. for cardiac diseases and 20% for respiratory diseases in people 65 and more are elective, i.e. non-emergency, admissions.

Appendix 5. Table 1. - Characteristics of the information sources for mortality data.

CITY	Type of source	Year	Source	Quality control programme	% Missing data in basic cause death	Codification		
						ICD	Manual	Automatic
Athens	Register	1996	National statistical Service of Greece;	–	–	ICD9	100%	
Barcelona	Register	1999	Barcelona city council.	yes	0%	ICD9	100%	
Bilbao	Register	1998	Mortality Register of the Basque Autonomous Community;	yes	0%	ICD9	100%	
Bordeaux	Register	1998	Institut National de la Santé et de la Recherche Médicale (CepiDC)	yes	0%	ICD9	100%	
Bucharest	Register	1999	Medical Statistics Centre. Ministry of Health and Family and National Institute of Statistics	–	–	ICD10	–	
Budapest	Register	1999	Central Statistical Office, Budapest	yes	0,19%	ICD10	100%	
Celje	Register	1999	Institute of Public Health of the Republic of Slovenia	yes	0%	ICD10	100%	
Cracow	Register	1996	Department of Medical Statistics, NIH	yes	0,1%	ICD9	100%	
Dublin	Register	1998	National Register, Central Statistics Office	yes	0%	ICD9	100%	
Gothenburg	Register	1999	National Registry	yes	0,8%	ICD10	100%	
Le Havre	Register	1998	Institut National de la Santé et de la Recherche Médicale (CepiDC)	yes	0%	ICD9	100%	
Lille	Register	1998	Institut National de la Santé et de la Recherche Médicale (CepiDC)	yes	0%	ICD9	100%	
Ljubljana	Register	1999	Institute of Public Health of the Republic of Slovenia	yes	0%	ICD10	100%	
London	Register	1999	Office for National Statistics	yes	3%	ICD9	–	100%
Lyon	Register	1998	INSERM	yes	0%	ICD9	100%	
Madrid	Register	1998	Mortality Register. Statistics Institute. Madrid Autonomous Community	yes	0,18%	ICD9	40%	60%
Marseille	Register	1998	Institut National de la Santé et de la Recherche Médicale (CepiDC)	yes	0%	ICD9	100%	
Paris	Register	1998	INSERM SC8	yes	0%	ICD9	100%	
Rome	Register	1999	Registro Nominativo delle cause di morte;Regione Lazio	yes	<0,1%	ICD9	100%	
Rouen	Register	1998	Institut National de la Santé et de la Recherche Médicale (CepiDC)	yes	0%	ICD9	100%	
Seville	Register	1999	Mortality Register of Andalusia.	yes	0%	ICD9	100%	
Stockholm	Register	1999	National Registry	yes	0,8%	ICD10	100%	
Strasbourg	Register	1998	Institut National de la Santé et de la Recherche Médicale (CepiDC)	yes	0%	ICD9	100%	
Tel-Aviv	Register	1996	Department of Information. Ministry of Health	yes	4,6%	ICD9	100%	
Toulouse	Register	1998	Institut National de la Santé et de la Recherche Médicale (CepiDC)	yes	0%	ICD9	100%	
Valencia	Register	1999	Mortality Register of the Valencian Community	yes	0%	ICD10	55%	45%

Appendix 5. Table 2. - Characteristics of the information sources of hospital admission data on cardiac and respiratory diseases.

CITY	Type of source	Year	Source	ICD	Quality control	Completeness (%)	% Missing data cause admission	Type of H. admissions	
								Total	Emergency
Barcelona	Register	1999	Minimum set of Basic Hospital Data	9	Yes	70	0.2		X
Bilbao	Register	1998 2000	Hospital Discharge Register. Basque Autonomous Community	9	Yes	99.9	0.3		X
Bordeaux	Register	1997	PMSI	10	Yes	–	0	X	
Bucharest	Register	1999	Medical Statistic Centre of the Ministry of Health and Family	10	–	–	–	X	
Celje	Register	1999	Institute of Public Health of the Republic of Slovenia	10	Yes	100	0	X	
Gothenburg	Register	1999	National Hospital Discharge Register	10	Yes	>99	1		X
Le Havre	Register	1998	PMSI	10	Yes	–	0	X	
Lille	Register	1998	PMSI	10	Yes	–	0	X	
Ljubljana	Register	1999	Institute of Public Health of the Republic of Slovenia	10	Yes	100	0	X	
London	Register	1999	Health Episodes Statistics	10	Yes	–	–		X
Lyon	Register	1999	PMSI	10	Yes	>95	0	X	
Marseille	Register	1998	PMSI	10	Yes	–	0	X	
Paris	Register	1998	PMSI de L´Assistance Publique des Hôpitaux de Paris	10	Yes	100	0	X	
Rome	Register	1999	Sistema Informativo Ospedaliero (SIO)	9	Yes	96	0.1	X	
Rouen	Register	1998	PMSI	10	Yes	–	0	X	
Seville	Register	1999	Minimum set of Basic Hospital Data. Andalusia Health Service	9	Yes	100	0.3		X
Stockholm	Register	1999	National Hospital Discharge Register	10	Yes	>99	1		X
Strasbourg	Register	1998	PMSI	10	Yes	–	0	X	
Tel-Aviv	Register	1996	Department of Information. Ministry of Health	9	Yes	100	3	X	
Toulouse	Register	1998	PMSI	10	Yes	–	100	X	
Valencia	Register	1999	Minimum set of Basic Hospital Data	9	Yes	85	–		X

City	Type of Source	Year	Source	ICD	Sample size	Coefficient of variation	Type of H. admissions
Madrid	Survey	1998	Hospital Morbidity Survey. National Statistics Institute.	9	25% of Hospital discharges	– Respiratory diseases: 2% – Cardiac diseases: 2%	Emergency

Athens, Budapest, Cracow and Dublin have not estimated the impact on hospital admissions

Appendix 5 questionnaire

City:

Mortality data

1. Type of source: register
2. Source (name and year):
3. Quality control program: yes ☐ no ☐ don't know ☐
4. Percentage of cases registered with missing data in the basic cause of death:
5. Codification: manual (%) / automatic (%)
   ICD9: yes ☐ no ☐

Hospital admission data
A) Type of source: Survey

1. Source: (name and year)
2. Definition of episodes included:
3. Periodicity: annual or other
4. Sample size: (percentage of total annual hospital admissions in your city)
5. Relative error (coefficient of variation) (95% C.I.) for emergency hospital admissions for:
   – Respiratory diseases >65 years (ICD9: 460-519):
   – Cardiac diseases (410-414, 427, 428): (95% C.I.):
6. Codification ICD9: Yes ☐ No ☐
7. Type of hospital admissions considered in the analysis:
   – total admissions ☐ – emergency admissions ☐

B) Type of source: Register

1. Source: (name and year)
2. Definition of episodes included:
3. Codification: ICD9.
4. Quality control program: yes ☐ no ☐ don't know ☐
5. Completeness of the register (% of total annual episodes of hospital admissions registered):
6. Percentage of cases registered with missing data in the cause of admission (as a quality indicator):
7. Type of hospital admissions considered in the analysis:
   – total admissions ☐ – emergency admissions ☐

APPENDIX 6

Case studies of interventions to reduce air pollution levels in Dublin, Gothenburg and Stockholm

Summary of the Intervention to Reduce Particulate Pollution Levels in Dublin

Pat Goodman and Luke Clancy

Throughout the 1980s Dublin experienced severe particulate pollution events, with EU limits regularly breached. Kelly and Clancy[1] reported on a doubling of case fatality rates at a general hospital during a serious smog event in January 1982. The EU limit for black smoke at the time was 250 µg/m^3, individual monitoring stations regularly reported values greater than 1 000 µg/m^3, daily values averaged over a number of monitoring stations reached up to 880 µg/m^3.

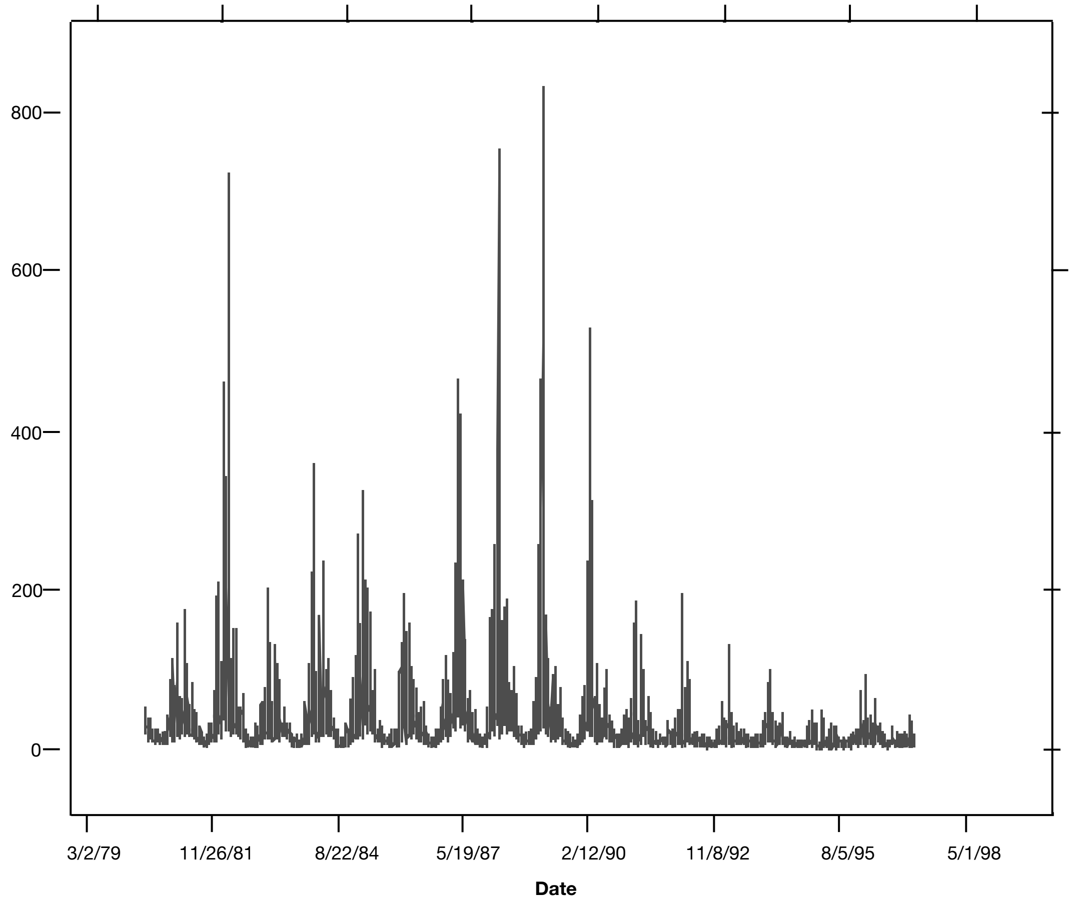
Domestic heating systems were viewed as being the major contributor to particulate pollution levels. Convery[2] reported that, in 1984, all social housing and 80% of private housing in Dublin used solid fuel as a means of space heating. Throughout this period the government had given householders a grant to install solid fuel based heating systems. This was in response to the 1970 world oil crisis, and to an attempt to reduce the nations dependence on imported oil.

The health effects report led to public pressure on the government to take some form of intervention to reduce pollution levels. In 1987 they tried introducing a *smoke free zone* in one of the worst polluted areas; this did not prove to be successful as it was difficult to enforce. The government then introduced legislation[3] that came into effect from the 1st September 1990. This banned the marketing, sale and distribution of smoky coal in the greater Dublin area. This proved very successful as it targeted the supply of coal and was a lot easier to enforce. In addition to this, natural gas had become available in Dublin, and were attractive financial packages were available to allow householders to convert their heating systems to natural gas.

The ban on smoky coal proved to be immediately successful at reducing particulate pollution levels.

		Total	Autumn (Sept-Nov)	Winter (Dec-Feb)	Spring (Mar-May)	Summer (Jun-Aug)
Black Smoke (µg/m^3)						
Pre-ban	1984-90	50.2	62.4	85.4	39.6	14.4
Post-ban	1990-96	14.6	18.3	21.5	10.9	8.2
	Change	–35.6	–44.1	–63.8	–28.7	–6.2
Sulfur Dioxide (µg/m^3)						
Pre-ban	1984-90	33.4	35.7	40.4	31.2	26.3
Post-ban	1990-96	22.1	21.7	24.9	21.2	20.7
	Change	–11.3	–14.1	–15.5	–10.0	–5.6

The results in the table above show that, when the 6 years before the introduction of the ban on smoky coal were compared with the 6 years after the introduction of the ban, particulate pollution levels fell by over 50%. The biggest decrease was in wintertime when particulate levels fell by over 63%. The change in sulphur dioxide levels was not as dramatic, however. Sulphur dioxide levels never reached the extreme high values in the period before the ban in comparison to the high concentrations of particulates that had been recorded.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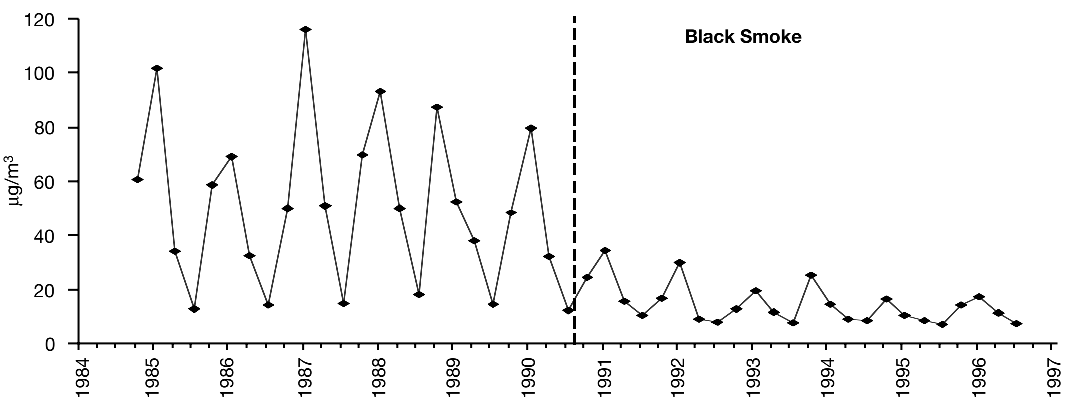
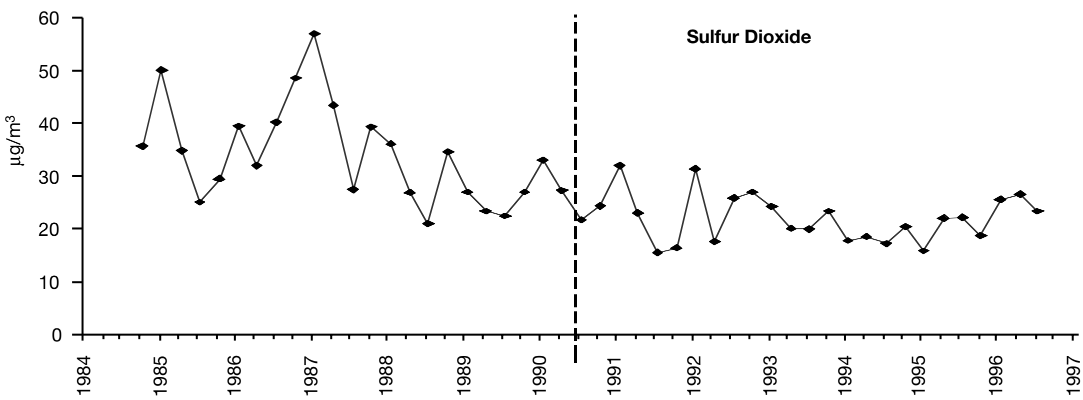
600
400
200
0
3/2/79
11/26/81
8/22/84
5/19/87
2/12/90
11/8/92
8/5/95
5/1/98
Date


Black Smoke
µg/m3
120
100
80
60
40
20
0
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997


Sulfur Dioxide
µg/m3
60
50
40
30
20
10
0
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997

The graphs above show the dramatic change in particulate pollution levels that occurred with the introduction of the ban on smoky coal in Dublin. Apart from the decrease in average particulate pollution levels, it is also quite noticeable that the peaks or maximum values have fallen significantly. Because of the success of this intervention, the Irish government have extended it to cover other large urban areas, with similar results being reported.

Health Implications

An initial report on the health implications of this intervention was presented at the ERS meeting in Geneva 1998[4]. A detailed paper on this intervention has been accepted for publication[5].

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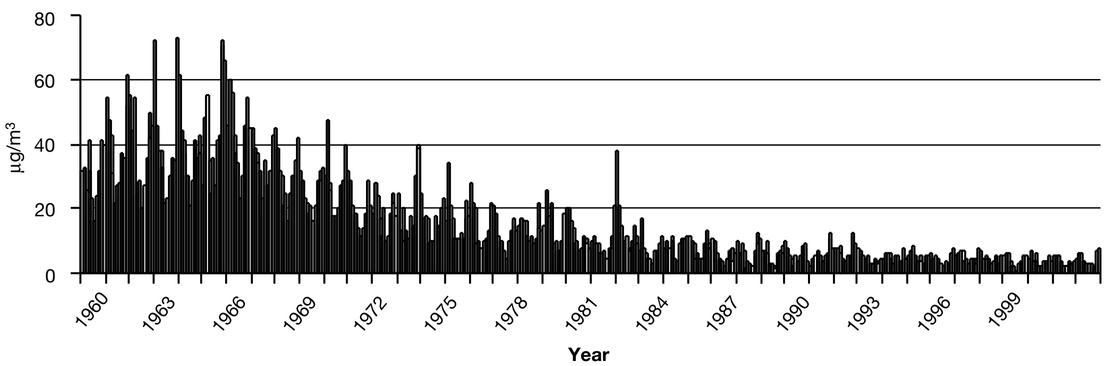
Case Study - Marked Improvements in Air Quality in Gothenburg

Bertil Forsberg and Jesper Lindgren

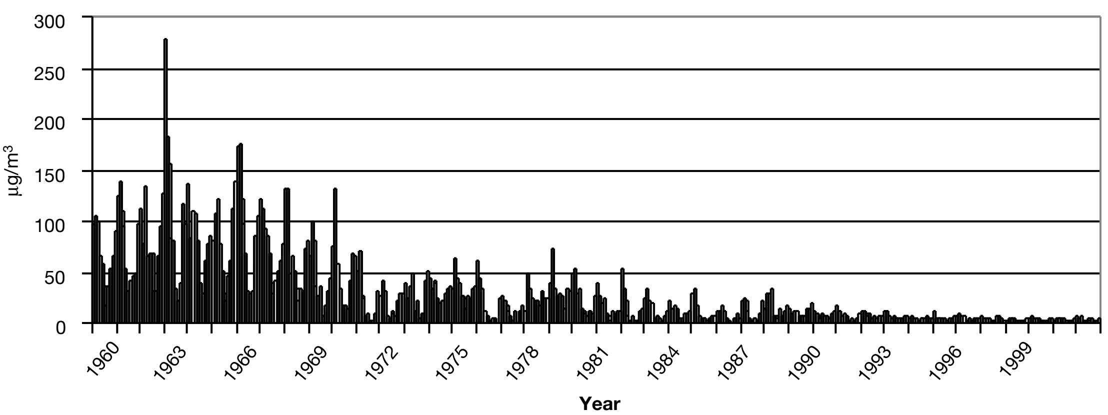
With 467,000 inhabitants, Gothenburg is Sweden's second-largest city. It lies at the mouth of the Göta Älv river on the Skagerrak coast, and its business character has been shaped by shipping and automobile manufacturing. By European standards, Gothenburg is today part of the industrial cities with rather good air quality. It has not always been that way. There have been marked improvements in the air quality in Gothenburg in the past 30 years. The levels of black smoke, sulphur dioxide, carbon monoxide and lead have declined sharply. Low levels were already reached many years ago, and thus the decline during the last 10 years has been slower.

Monthly mean levels of black smoke in Gothenburg, 1960-2001



Improvements in black smoke levels in air have been achieved thanks to plants, dust collectors and the expansion of the municipal heating network. Since 1994, BS has been estimated from PM measurements.

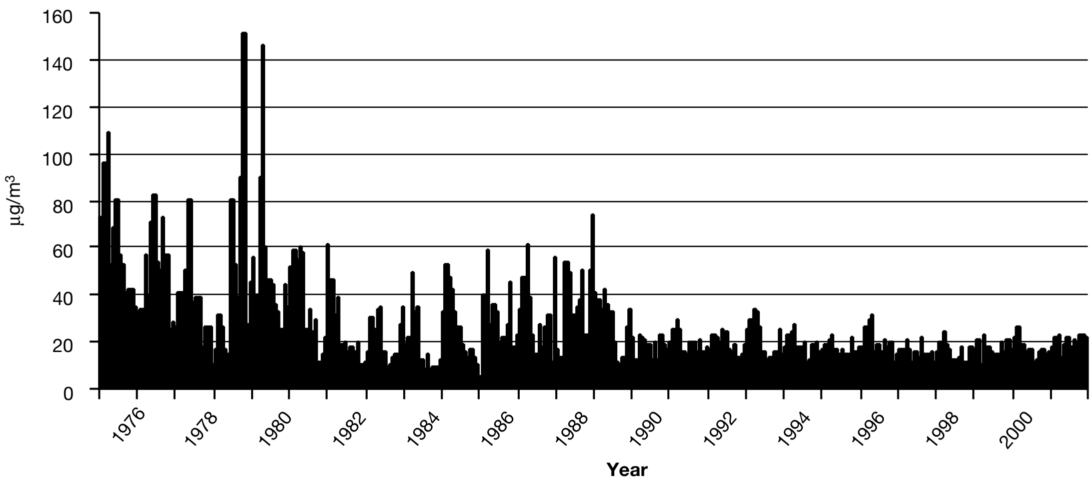
Monthly mean levels of SO_2 in Gothenburg, 1960-2001



Improvement in sulphur dioxide is largely due to the reduction of sulphur in the fuel starting in 1971.

Various measures have enabled such improvements: extensions to the district-heating grid were installed many years ago, emissions from industries have declined due to dust collectors, and the sulphur content in heating oil and diesel oil for vehicles has been reduced. Traffic emissions have also declined, thanks to catalytic converters, engine development and better fuels. More and more buses run on natural gas than on diesel fuel. Environmental zones have been introduced to stop polluting vehicles from going into the centre of Gothenburg. This has led to a reduction in emissions from heavy traffic. About 96% of the vehicles that use these zones comply with the requirements.

Monthly mean levels of PM_{10} in Gothenburg, 1976-2001

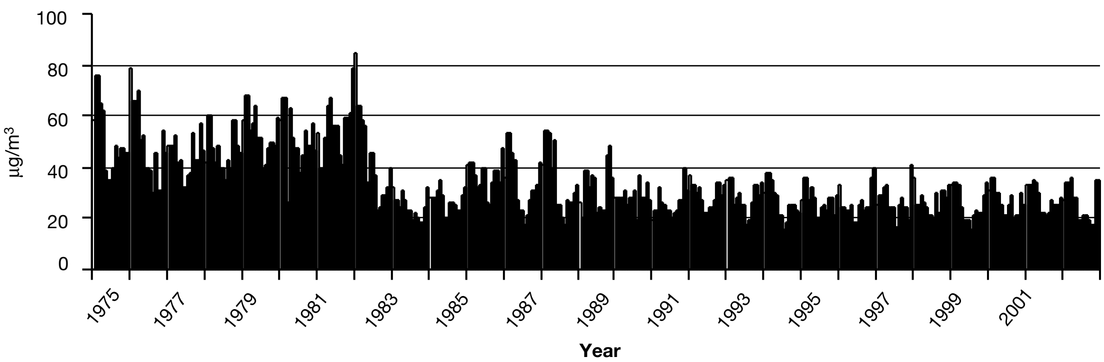


PM levels have also been decreasing slightly also in recent years.

The air today and tomorrow

If the quantities of particles, sulphur, carbon monoxide and lead have declined sharply, such progress has not been achieved for other pollutants, such as nitric oxides and benzene, due to increasing traffic. The level of air pollution also depends greatly on the place, time of year and day. The air least polluted by car exhausts is found in the outer areas of Gothenburg. The air is worst in the major thoroughfares in low-lying terrain. The Gothenburg agreement ("Göken") achieved environmental improvements, such as the extension of tramways ("Kringen") and investments in terminals and bus stops for public transport. The number of cars running on alternative fuels in the municipality is increasing. The City Council implemented the "Environmental Vehicles in Gothenburg" project, whose aim is to increase substantially the number of environment-friendly vehicles in the region by the year 2003. Half the vehicles used in the city's own activities will be replaced, which currently involves about 800 vehicles.

Monthly mean levels of NO_2 in Gothenburg, 1975-2001



In the past 10 years, levels of NO_2 discharges have remained the same despite increasing traffic, thanks mostly to catalytic converters, which became compulsory for 1989 cars.

Case Study of Stockholm: Improvements in Air Pollution Due to Recent and Historical Steps

Lars Modig and Christer Johansson

Stockholm County has approximately 1.8 million inhabitants, which corresponds to about 20% of the overall Swedish population. The majority of the inhabitants live in 21 parishes. The Apheis study area includes in total 41 parishes and has a population of 1.16 million people, with 15.6 % older than 65 years.

The growth of Stockholm's population is linked to the industrial revolution, and the migration from rural areas, which started at the beginning of the 19th century. A consequence of this increasing urbanisation is the steam produced by the various kinds of environmental pollution, the major sources in Stockholm being heating, industry and traffic.

In the beginning of the last century, heating was a considerable source of pollution due to many small wood and coal burning furnaces, which among other things resulted in high levels of black smoke and hydrocarbons. Gradually, larger central heating systems replaced small wood stoves, and the levels of BS and hydrocarbons decreased. Nevertheless, at the same time, heating oil was introduced as a fuel, which dramatically increased the emissions of sulphur dioxide.

At the beginning of the 1960s, levels of sulphur dioxide in the central parts of Stockholm exceeded 100 $\mu g/m^3$ (Figure 1) and during the winter months the concentration could rise above 200 $\mu g/m^3$. The work of reducing the SO_2-emissions already started in the beginning of 1950s when the first district heating system was built. The main purpose was not only to reduce the levels of air pollution, but also to generate electricity.

District heating systems developed gradually, and during the 1960s approximately 4% of the produced energy was generated by district heating; in the 1970s the percentage had reached 33%, and 61% in the middle of the 1990s.

The most important decrease in SO_2 concentrations was seen between 1965 and 1972; in some parts of the city the levels decreased by approximately 100 $\mu g/m^3$. This dramatic decrease was not only a result of district heating, but also of regulations on the amount of sulphur in heavy oils. In 1968, a regulation (SFS 1968:551) set the maximum percentage of sulphur in heavy oils at 2.5% (before the regulation, the average percentage was 3-4%). This regulation was successively tightened, and in 1984 the maximum amount of sulphur was 1%.

During the 1980s, the levels of SO_2 fell below 50 $\mu g/m^3$ in most parts of Stockholm, and in 1995 the concentrations were on average 5 $\mu g/m^3$, which corresponds to twice the background level.

In a study made by the Stockholm Environment and Health Protection Administration, a model calculation was made to describe the levels of sulphur in the absence of district heating (Johansson et al). The results show that inner city parts of Stockholm would have had two to six times higher concentrations of SO_2 and more rural areas 10-30 % higher compared to the actual levels of 1995.

The Stockholm region initiated the development of an environmental protection plan in the early 1970s, with the aim of developing guidelines for further environmental work. This work was somewhat focused on air pollution but also on other issues such as traffic noise and sewage storage.

While emissions from heating-related combustion sources decreased, traffic was becoming the main source of air pollution in the city of Stockholm. The number of passenger cars passing through Stockholm city decreased somewhat between 1975 and 1980, but increased more or less constantly during the 1980s. A peak was observed in 1989 followed by a small reduction, and throughout the 1990s the traffic was quite constant. The urban background levels of NO_2 were rather stable between 1982 and 1989, despite the increasing traffic, and the yearly averages were approximately 30 $\mu g/m^3$. This might be a result of developing district heating.

In 1989, the Swedish government decided to implement restrictions on exhaust fume emissions from newly built cars. In practice, this meant restrictions on new cars without catalytic-equipped engines. About 10% of the private cars in Stockholm had catalytic engines in 1990, and in the middle of the

1990s the percentage was up to 50-60%. In 1992/1993, restrictions regarding exhaust emissions were tightened also for heavy traffic. This had a positive effect on the NO_x emissions, and the urban background levels dropped. Also, in 1989, Stockholm County revised its environmental protection plan, which indirectly resulted in mounting numbers of citizens using by public transportation. These actions have had clearly positive effects on the air pollution levels in Stockholm, not only on the levels of NO_x and SO_2 but also on the concentrations of BS, CO, particulate matter and hydrocarbons. Measurements of PM did not start until 1992, and up to now there has not been any obvious trend in concentrations. The tightened regulations regarding emissions from vehicles, and the rising price of petrol/diesel fuel has forced the car industry to improve its products, which of course also contributes to the lowering of emission levels. The introduction of buses running on alternative fuels, like ethanol, has also been an important aspect for mainly reducing the amount of emitted carbon dioxide. In 1995, approximately one quarter of the local buses in Stockholm city used ethanol.

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Figure 1. Modelled and measured sulphur dioxide levels in Stockholm during the 1960s.