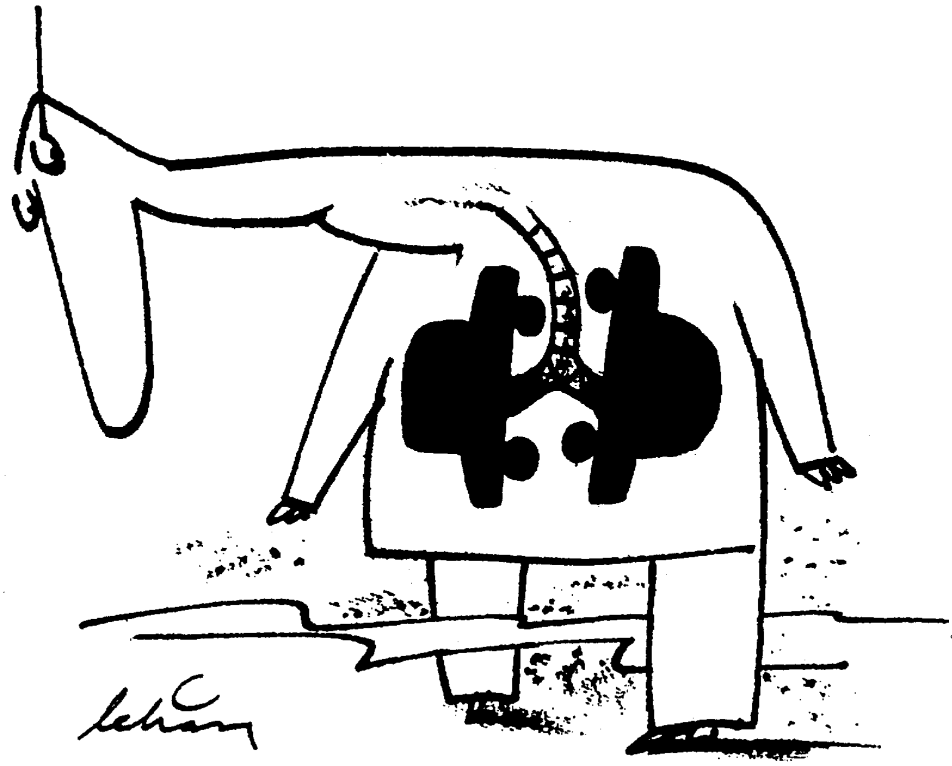
AIR POLLUTION AND HEALTH



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Although the concentrations of air pollutants are in general on the way down in Europe, the problems remain considerable – especially as regards ground-level ozone and small particles. In some parts, too, the situation continues to become worse. In the following is a digest of the chief effects, causes, and permissible limits to the concentrations of the most pervasive pollutants.

Air pollution is not easily measured, comprising as it almost invariably does a mixture of many different substances, some of which are more toxic than others. By interacting in some cases, they become even more harmful.

The effects of breathing toxic substances may range from a slight feeling of discomfort to premature death. Those most at risk are children, the elderly, asthmatics and persons with heart and circulatory problems. Sensitivity varies very widely, however, from one individual to another.

Target values and limit values

A number of target values and limit values have been set up with the aim of confining the pollutants to permissible levels.

Target values, such as those from the World Health Organization, are only recommendations, and so not binding. These are set at levels aiming to protect human health.

Limit values on the other hand are binding, and because they are compulsory, their economic consequences have been taken into account when deciding on them.

It has not been possible to determine any minimum dose below which there will be no ill effects from carcinogenic substances. Resort has therefore been made to a **medicinal low risk level** that will keep the risk of getting cancer under a certain level, for example 1 in 100,000, for individuals who are exposed to the specified concentration throughout their lifetime.

The risk to health come mainly from the following pollutants in the outdoor air:

Nitrogen dioxide

When inhaled, nitrogen dioxide can penetrate relatively deep into the airways, where it can cause irritation and damage to tissue. It can also aggravate both asthma and allergic reactions. It impairs, too, the defence

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For a more extensive version of this factsheet, see our website: www.acidrain.org/health.htm mechanisms of the lungs against bacteria, viruses, and other air pollutants such as ozone and particulate carcinogens. Repeated exposure to nitrogen dioxide, either alone or in combination with other factors, is suspected of starting off asthma in children.

Nitrogen oxides moreover have significant indirect effects on health through their contribution to the formation of ground-level ozone and the conversion in the air to very small particles. See below.

The main contributor to the concentrations of nitrogen oxides in urban surroundings is usually road traffic, although in some cities combustion plants make a significant contribution. The target and limit values applying at present are shown in Table 1.

Sulphur dioxide

Sulphur dioxide also causes irritation of the airways. Long-term exposure in combination with airborne particles increases the likelihood of respiratory infections in children. Further effects on health can be traced to the part played by sulphur dioxide in the formation of particles in the air (see below).

Sulphur dioxide can occur in high concentrations during periods of inversion. It was probably the most harmful component of the smogs that plagued London in the early 1950s, costing thousands of lives.

In most parts of Europe the levels of sulphur dioxide have fallen considerably in recent decades. Main emission sources is the burning of coal and oil. The contribution from traffic is small. Current target and limit values are given in Table 2.

Particles

Through the use of sophisticated statistical methods and more powerful computers, researchers have been able to identify links between exposure to particles and a variety of effects on health even at levels that had previously been considered safe.

A large number of studies made both in the US and in Europe have shown that when the concentration of small particles in air rises, even from low levels, there is a rise in mortalities from respiratory, cardiac and circulatory diseases, and more people seek hospital care for bronchitis and asthma. It is not known exactly how these particles cause damage, but they are thought likely to excite and aggravate inflammations of the airways.

Even exposure to low levels for long periods is considered harmful. The long-term effects have not yet been so well researched, but living in regions where there are high concentrations of particles is believed to reduce life expectancy.

Calculations have shown that in Austria, Switzerland, and France (Künzli et al, 2000) small particles (PM_{10}) at current levels in air give rise to 40,000 premature deaths a year in these countries, and the average life expectancy of people living in an urban environment to be reduced by 18 months. Furthermore, they start off half a million asthma attacks each year and lead to a total of 16 million lost person-days of activity.

It is the very smallest particles that are believed to be the most harmful, because when they are inhaled they can penetrate deep into the lungs. Their shape and chemical composition as well as their size are thought to influence their harmfulness, as do the substances that adhere to their surface.

Particles are now generally measured as PM_{10}, where PM stands for particulate matter and the number 10 indicates the maximum diameter in micrometers (actually particles of such a size that 50 per cent pass through a given sampling filter). For several years an even finer fraction, $PM_{2.5}$, has also been measured in the US. This gives a better measure of the

Table 1. NITROGEN DIOXIDE (µg/m^3)

	1-hour mean value	Annual mean value
WHO target value (WHO 2000)	200	40 (health) 30 (vegetation; $NO+NO_2$)
EU limit value, applies from 2010 (A)	200 (B)	40 (health) 30 (vegetation; $NO+NO_2$) (C)

(A) European Union 1999. (B) Must not be exceeded more than 18 times per calendar year. (C) Applies from 19 July 2001.

Table 2. SULPHUR DIOXIDE (µg/m^3)

	10-min. mean value	1-hour mean value	Max. 24-h. mean value	Annual mean value
WHO target value (WHO 2000)	500	-	125 (health)	50 (health) 10-30 (ecosystem)
EU limit value, from 2005 (A)	-	350 (B)	125 (C)	20 (D)

(A) European Union 1999. (B) Must not be exceeded more than 24 times per calendar year. (C) Must not be exceeded more than 3 times per calendar year. (D) To protect ecosystem. Applies outside urban areas, with effect from 19 July 2001.

Table 3. PARTICLES (PM_{10}, µg/m^3)

	Max 24-hour mean value	Annual mean value
WHO target value (WHO 2000)	dose response	dose response
EU limit value, from 2005 (A)	50 (B)	40
Prel. EU limit value 2010 (A)	50 (C)	20
Guide value proposed by IMM (D)	30	15
Current levels in Europe		10 (remote areas) 100 (heavily polluted areas)

(A) European Union 1999. (B) Not to be exceeded more than 35 times per year. (C) Not to be exceeded more than 7 times per year. (D) IMM = National Institute of Environmental Medicine, Sweden. See Pershagen 2000.

very smallest particles, and presumably a better indication of the effect on health. In recent years a start has been made on measuring $PM_{2.5}$ in the EU too, although the present standards only apply to PM_{10}. A change in the EU standards will be discussed when the current directive is revised in 2003.

Particles are classed as either primary or secondary:

Primary particles are those that are formed during combustion, but may also consist of dust, small soot flakes, pollen, etc. Major sources are combustion processes (often small-scale burning) and internal combustion engines (primarily diesel engines). At present the extent of these emissions and their distribution among sources are not fully known.

Secondary particles consist mainly of sulphate and nitrate salts that are formed in the air from sulphur dioxide and nitrogen oxides. Any source that emits these substances therefore contributes to their formation.

Secondary particles are small and can remain suspended in the air for long periods. There is an extensive transboundary migration – in most places only a small proportion is traceable to local emissions, and a large percentage, particularly of the finest fractions, consists of secondarily formed particles. In urban areas in Europe 30-70 per cent of the measured levels of $PM_{2.5}$ derives from particles brought in from afar, while the figure for rural areas is closer to 100 per cent.

The WHO guidelines do not set any target values for airborne particles, since it is considered unlikely that a level will be found that does not have harmful effects. In Sweden the National Institute of Environmental Medicine (IMM) has proposed limit values well below the levels so far considered acceptable. See Table 3.

According to calculations by the EU Commission for 1995, almost 90 per cent of Europe's urban population was living in areas where particle levels exceeded the maximum 24-hour mean and annual mean values of the forthcoming EU standard. This proportion is expected to fall to around two-thirds by 2010 as a result of decisions already taken in respect of emission controls for combustion plants and vehicles, as well as of sulphur levels in fuels (European Commission, 2000).

Table 4. BENZENE (µg/m³)

	Annual mean value
EU limit value, applies from 2010 (A)	5.0
Low risk level (B)	1.3
Current levels, urban environment, Europe	1-10 (background level) 20-50 (roadside)

(A) European Union 2000. (B) Assessment by National Institute of Environmental Medicine, Sweden. Lifetime exposure to this concentration gives rise to 1 case of cancer per 100,000 inhabitants.

Table 5. OZONE (ppb; 1 ppb = 2 µg/m³)

	1-hour mean value	8-hour mean value	3-month mean value
WHO target value (WHO 2000)		60 (health)	
Current EU target values (A)	90/180 (B)	55	
Proposed EU target value (C)		60 (D)	AOT40(E) =3,000 ppb-hours (F)
Proposed target value (G)	40 ppb		

(A) European Community 1992. (B) 90 ppb is the level at which the public must be informed, 180 ppb that at which a warning must be issued. (C) European Commission 1999. (D) Interim target 2010: not to be exceeded more than 20 times per year. (E) AOT40 = Accumulated exposure over the threshold of 40 ppb. (F) Interim target 2010: AOT40=8.500 ppb-hours. (G) Bylin et al 1996.

Volatile organic compounds

These compose a very large group of pollutants. Some are fairly harmless, while others are extremely toxic. They can occur either as gases or bound to particles, and several of the substances in this group contribute to the formation of ground-level ozone – which is probably the most significant health effect of this group as a whole.

The group includes known carcinogens such as benzo(a)pyrene, ethene and benzene, as well as various aromatic hydrocarbons. Among the nitrated polyaromatic hydrocarbons (nitro-PAH) are some of the most carcinogenic substances known to man, several of which are present in diesel exhaust fumes.

Petrol-driven cars that are either without or have only ineffective catalytic converters are a main source of emissions of volatile organic compounds in urban air. Also small-scale combustion, such as the household burning of wood or coal, can make a significant contribution.

At present the limit values in the EU are only for benzene, but standards are also being worked out for polyaromatic hydrocarbons (PAH).

In most European cities the levels of benzene in the air exceed the medical low risk limits by a large margin. For current limit values and levels, see Table 4.

Ozone

Ozone is a powerful oxidant and can give rise to eye irritations and irritations of the airways that lead to a reduction in lung capacity, even at relatively low concentrations. Because ozone is a gas with low solubility in water it can penetrate deep into the lungs. During periods of elevated levels rises occur in the number of people who are admitted to hospital emergency departments with respiratory problems. When concentrations rise, even from relatively low levels, the need for increased medication of asthmatic children and increased mortality are among the observed effects.

High levels occur primarily in spring and summer, since ozone formation is a process that is driven by sunlight. Concentrations in Europe exceed by a large margin every year the levels at which health effects begin to appear. Following so-called episodes, high levels can also occur in areas with relatively clean air. However, the amount of ozone to which an individual is exposed will depend largely on how much time he or she spends outdoors – the indoor level always being much lower.

Following national and international agreements that will result in measures to reduce the emissions of nitrogen oxides and volatile organic compounds, ozone levels are expected to fall over the next few decades. Levels over Europe are however also affected by emissions from all over the northern hemisphere, which means that increasing emissions in Asia, for example, could counteract this trend. For target values and current levels, see Table 5.

Asthma and allergies

In many industrialized countries the incidence of asthma and allergies has risen sharply in recent decades. So far no explanation has been found. The incidence of hypersensitive reactions is thought to be due to hereditary dispositions as well as environmental factors. One as yet unexplained phenomenon is the much greater increase in western than in eastern Europe.

Researchers do not believe that air pollution is a critical factor that could account for this rise or for the differences between countries. Nevertheless air pollution does play an important role in this context. Nitrogen dioxide, sulphur dioxide, ozone, and particles have all been shown to aggravate and in some cases start off symptoms of asthma in susceptible individuals. Ozone and nitrogen dioxide have also been proved to increase sensitivity to pollen among sufferers from hay fever. This is because these pollutants damage the mucous membranes of the airways, so that allergenic substances are more likely to trigger a reaction.

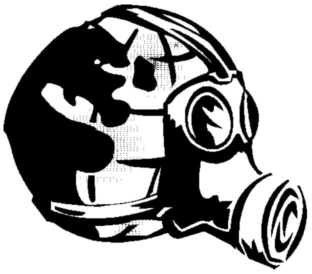
Preventive measures are profitable

Numerous studies have shown it to be economically profitable to greatly reduce the emissions of air pollutants, with the greater part of the gain lying in the reduction of negative effects on people's health.

One example is the cost-benefit analyses that have been carried out to illustrate the effect of implementing the Gothenburg Protocol under the Convention on Long Range Transboundary Air Pollution (Holland 1999; Amann 1999). Whereas the annual cost of doing so is estimated to be 2.8 billion euros for 2010, the annual profit would be 12.8 billion euros, or four times greater than the cost.

If countries chose to reduce emissions even further (in line with the so-called G5/2r scenario) the cost would rise to 8.5 billion euros a year for 2010, but the profit even more, to an enormous 42.3 billion euros.

In both cases the most important item on the profit side is the reduced damage to people's health, primarily as result of lowered levels of harmful particles.



References

Amann, M. et al. 1999. Integrated Assessment Modelling for the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone in Europe**.** Publicatiereeks lucht & energie nr. 132. Dutch Ministry of Environment, Distributiecentrum VROM, Zoetermeer, The Netherlands.

Bylin G., et al, 1996. Health risk evaluation of ozone. Scand J. Work, Environ. Health. 1996; 22 Suppl. 3:1–102.

European Commission 1999. Proposal for a Directive of the European Parliament and of the Council relating to ozone in ambient air. COM (1999) 125(02)

European Commission 2000. A Review of the Auto-Oil II Programme. COM2000(626).

European Community 1992. Council Directive 92/72/EEC of 21 September 1992 on air pollution by ozone. *Official journal NO. L 297, 13/10/1992 P. 0001 - 0007*

European Union, 1996. Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management. *Official Journal L 296 , 21/11/1996 p. 0055 – 0063.*

European Union, 1999. 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*

European Union, 2000. Directive 2000/69/EC of the European Parliament and of the Council of 16 November 2000 relating to limit values for benzene and carbon monoxide in ambient air. *Official Journal L 313, 13/12/2000 p. 0012.*

Holland, M. et al. 1999. Cost-Benefit Analysis for the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone in Europe. Publicatiereeks lucht & energie nr. 133. Dutch Ministry of Environment, Distributiecentrum VROM, Zoetermeer, The Netherlands.

Künzli, N. et al, 2000. Public health impact of outdoor and traffic-related air pollution: a European assessment. The Lancet. Vol. 356. September 2, 2000.

Pershagen G. (ed) 2000. Particles in ambient air – a health risk assessment. Scand. J. Work Environ. Health 2000;26 suppl. 1:1–96.

WHO 2000. Air Quality Guidelines for Europe, second edition, WHO Regional Office for Europe, 2000, Copenhagen.

Information on the Internet

WHO Europe: www.who.int/peh/air/Airqualitygd.htm

European Commission: www.europa.eu.int/comm/environment/air/index.htm

European Environment Agency: www.eea.int

Health Effects Institute: www.healtheffects. org

EMEP: www.emep.int (data on emissions, long-range transboundary air pollution and the deposition of pollutants)

International Institute for Applied System Analysis: www.iiasa.ac.at/~rains (information on particles, etc.)

The EU framework directive

In September 1996 the EU Council of Ministers adopted the directive on ambient air quality assessment and management (96/62/EC). This is a framework directive which, among other things, lays down how monitoring systems should be set up so as to make information on measurements readily accessible to the public.

So far it has been supplemented by two daughter directives. The first was adopted in 1999 and covers sulphur dioxide, nitrogen dioxide, particles (PM_{10}) and lead (1999/30/EC). The second, covering benzene and carbon monoxide, was adopted in 2000 (2000/69/EC). A proposal for target values for ozone was presented by the Commission in 1999 (European Commission 1999) and a decision is expected in 2001. Work is in progress on proposals for polyaromatic hydrocarbons (PAH) and a number of heavy metals.

The framework directive says nothing about how the limit values should be achieved; that is up to each member country to decide. It does however require that corrective measures should be taken if the standards are not being met. The specified limit values are minimum standards, which means that member countries can introduce stricter standards if they wish.