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REPORT

drawn up on behalf of the Committee on the Environment, Public Health and Consumer Protection

on the combating of acid rain

Rapporteur: Mr H. MUNTINGH

PE 86.241/fin.

English Edition

At its meeting of 13 May 1982 the European Parliament referred the motion for a resolution by Mr Mertens and others (Doc. 1-239/82), pursuant to Rule 47 of the Rules of Procedure, to the Committee on the Environment, Public Health and Consumer Protection, as the committee responsible, and to the Committee on Economic and Monetary Affairs, for its opinion.

At its meeting of 23 June 1982 the committee decided to draw up a report, and appointed Mr Muntingh rapporteur.

The European Parliament also referred the motions for resolutions by Mrs Weber and others (Doc. 1-1267/82), Mr Bocklet and others (Doc. 1-1268/82), Mr von Wogau and others (Doc. 1-27/83), Mr Schieler (Doc. 1-102/83), and Mr Eisma (Doc. 1-904/83) to the Committee on the Environment, Public Health and Consumer Protection, as the committee responsible, and to the Political Affairs Committee (Docs. 1-182/83 and 1-904/83), the Committee on Agriculture (Docs. 1-1268/82 and 1-27/83), the Committee on Budgets (Doc. 1-1267/82), and the Committee on Energy, Research and Technology (Docs. 1-1267/82, 1-1268/82, 1-102/83 and 1-27/83) for their opinions.

The committee decided to incorporate all the above motions for resolutions in its report.

It considered this matter on 23 March 1983, held hearings on 19 and 20 April 1983,and considered the draft report at its meetings of 18 October, 3 November and 30 November 1983. At the last such meeting the committee adopted the motion for a resolution unanimously with one abstention.

The following took part in the vote : Mr Collins, chairman; Mr Ryan, vice-chairman; Mrs Weber, vice-chairman; Mr Muntingh, rapporteur; Mr Bombard, Mr Eisma, Mr Forth, Mr Ghergo, Mrs Van Hemeldonck, Mrs Krouwel-Vlam, Mr Le Roux, Mr Mertens (deputizing for Mr Alber), Mrs Pantazi-Tzifa, Mr Petersen (deputizing for Mrs Seibel-Emmerling), Mr Protopapadakis (deputizing for Mr Del Duca), Mrs Pruvot (deputizing for Mrs Scrivener), Mrs Schleicher, Mr Seligman (deputizing for Miss Hooper), Mr Sherlock, Mrs Squarcialupi and Sir Peter Vanneck (deputizing for Mr Johnson).

The opinions of the Committee on Economic and Monetary Affairs and the Committee on Energy, Research and Technology are attached. The Political Affairs Committee will deliver an oral opinion, the Committee on Agriculture has decided to deliver no opinion, and the opinion of the Committee on Budgets will be delivered separately.

The report was tabled on 8 December 1983.

C O N T E N T S

The Committee on the Environment, Public Health and Consumer Protection hereby submits to the European Parliament the following motion for a resolution together with explanatory statement and annexes:

MOTION FOR A RESOLUTION

on the combating of acid rain

The European Parliament,

- having regard to the resolution of the Council of the European Communities and of the representatives of the Governments of the Member States, meeting within the Council, of 7 February 1983 on the continuation and implementation of a European Community policy and action programme on the environment (1982 to 1986)[1],

- having regard to the resolution of the European Parliament (Doc. 1-635/79) on the proposal from the Commission of the European Communities to the Council for a decision on the conclusion of the Convention on long-range transboundary air pollution[2],

- having regard to the Council decision of 11 June 1981 on the conclusion of the Convention on long-range transboundary air pollution (81/462/EEC)[3],

- having regard to the resolution of the European Parliament on the combating of photochemical pollution (Doc. 1-636/81)[4],

- having regard to the resolution of the European Parliament on the proposal from the Commission of the European Communities to the Council for a directive amending Directive No. 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by gases from positive-ignition engines of motor vehicles (Doc. 1-82/83)[5],

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[1] OJ No. C 46, 17.2.1983, p.1
[2] OJ No. C 59, 10.3.1980, p.71
[3] OJ No. L 171, 27.6.1981, p.11
[4] OJ No. C 125, 17.5.1982, p.163
[5] OJ No. C 184, 11.7.1983, p.131

- having regard to the resolution of the European Parliament on lead in petrol (Doc. 1-279/83)[1],

- having regard to the resolution of the European Parliament on the proposal from the Commission of the European Communities to the Council for a decision adopting a sectoral research and development programme in the field of environment (environmental protection and climatology) (indirect and concerted actions) 1981 - 1985, (Doc. 1-660/80)[2],

- having regard to the Council decision of 3 March 1981 on that programme (81/213/EEC)[3],

- having taken note of the conclusions and recommendations of the Second Stockholm Conference on acid rain (28-30 June 1982)[4],

- having regard to the motions for resolutions tabled by Mr MERTENS and others (Doc. 1-239/82), Mrs WEBER and others (Doc. 1-1267/82), Mr BOCKLET and others (Doc. 1-1268/82), Mr von WOGAU (Doc. 1-27/83) and Mrs SCHLEICHER and others (Doc. 1-102/83) and Mr EISMA (Doc. 1-904/83),

- having heard a number of experts in the field of air pollution and representatives of interest groups at a public hearing on acid rain organized by the European Parliament on 19 and 20 April 1983 in Brussels,

- having regard to the report of the Committee on the Environment, Public Health and Consumer Protection and the opinions of the Committee on Economic and Monetary Affairs, the Committee on Energy and Research, the Political Affairs Committee and the Committee on Budgets (Doc. 1-1168/83),

A. extremely alarmed at the increasing impact of acid rain on the natural environment manifesting itself in particular in the death of forests and lakes on a massive scale and the disappearance of entire ecosystems,

B. likewise extremely concerned at the damage caused by this phenomenon to valuable cultural assets and building materials,

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[1] OJ No. C 184, 11.7.1983

[2] OJ No. C 28, 9.2.1981, p.60

[3] OJ No. L 101, 11.4.1981, p.1

[4] See Part II of the annex

C. alarmed at the restricted growth in agricultural crops and pasture due to current levels of air pollution,

D. similarly aware of the harmful effects which this phenomenon has directly and indirectly on both mental and physical health,

E. aware that the main components of 'acid rain' are sulphur oxides, nitrogen oxides and their derivatives, heavy metals and hydrocarbons and also photochemical oxidants,

F. whereas the chief cause of acid rain is the combustion of fossil fuels,

G. whereas the main sources of air pollution can be roughly categorized as (a) power stations and urban heating installations, (b) traffic, (c) industry, (d) households and small users and (e) agricultural undertakings,

H. whereas large-scale fuel-burning installations are principally responsible for sulphur oxide pollution and traffic for nitrogen oxide pollution,

I. aware that the blighting of the natural environment observed in the Member States has not occurred to the same extent everywhere, but aware that the pattern of damage to cultural assets, building materials and public health is the same in all the Member States,

J. aware that the abovementioned effects are by no means limited to the Member States, but also occur in other European countries, e.g. Sweden, Poland and Czechaslovakia, sometimes on a larger scale,

K. aware that experts are still not fully agreed either on the exact process by which acid rain is formed or on the precise manner in which it inflicts damage,

L. convinced that clarification of how the cause-and-effect cycle operates is of the utmost importance, given that the resulting harm is apparent and that experts do not agree on the root cause, which, however, might be found in the above-mentioned form of air pollution,

M. whereas action must now be taken regardless of the existing, unresolved scientific questions,

N. whereas the total damage is estimated by the OECD, on the basis of an assessment of the damage to a limited number of products and crops at 3% - 5% of gross national product of the European Community or 60 to 80,000 million ECU per year,

O. whereas this calculation does not take into account the damage to forests, which is particularly apparent in the Federal Republic of Germany for instance, where 2 million hectares of woodland have already been damaged, although it is almost impossible to calculate the damage and it has to be feared that as a result of recent developments, this damage is considerably greater,

P. whereas this damage to forestry resources in the Federal Republic of Germany alone is responsible for an estimated loss of around 47,000 jobs, in the forestry and wood processing industry as well as the destruction of a capital asset to the value of some 10,000 million DM and an annual financial loss of 4,000 million DM for the wood-processing industry,

Q. whereas therefore the true extent of the damage is very likely to be greater than the estimate of 3% - 5% of GNP referred to above,

R. of the opinion that current legislation concerning the combating of air pollution is clearly totally inadequate,

S. of the opinion that the social benefits of implementing anti-pollution measures will great outweigh the social costs,

T. recognizing that techniques for combating pollution are commercially available and are in use outside the European Community, especially in Japan and the USA,

U. whereas among such techniques flue gas cleaning, improved combustion techniques and, in particular, fluidized bed combustion, fuel cleaning and energy saving should be considered,

V. recognizing also the valuable contribution to the reduction in air pollution which would be made by a significant increase in the use of nuclear energy,

W. pointing out that the legislation in force in the various Member States is characterized by its extreme diversity and therefore needs to be harmonized or replaced by new legislation at Community level,

X. noting that air pollution, being a transboundary phenomenon, is an example of a truly international problem,

Y. noting that by no means all European countries have ratified the 1979 Convention on long-range transboundary air pollution drawn up by the United Nations Economic Commission for Europe,

Z. noting that the reduction of SO_2 emission levels is only referred to in an annex to the Convention and that there is no mention at all of reducing NO_x emission levels,

AA. of the opinion that the problem of air pollution (acid rain) has developed into one of the major environmental problems of our time and of the European Community and therefore calls for swift and effective concerted action, including consultation with non-EEC countries, because only European legislation becomes law in all ten countries of the Community and these laws can be supervised and sanctioned on a national basis,

1. Calls on the Commission to draw up at an early date a major programme of of measures to combat air pollution containing the following long-term objectives:

   1. the introduction of technologies conducive to the restructuring of the energy-supply system
   2. the restriction of toxic emissions to a level which interferes as little as possible with the natural background level, in other words which is as close as technically possible to zero;

   3. promotion of the development of energy-saving techniques, and their introduction in order to minimize energy consumption in all areas of production, industry, and household management;

   In order to realize the long-term objectives and arrest the very serious damage caused, the following measures must be elaborated immediately for implementation as soon as possible :

   (a) Proposals in the form of directives setting emission standards and air quality standards for the most important air pollutants currently recognized (primarily sulphur dioxide, nitrogen oxide and heavy metals) and applicable to existing installations and lignite-fired power stations), in conjunction with

   (b) proposals for legislation in the form of regulations laying down emission standards/ceilings for each emission source or category of sources,

   (c) proposals in the form of regulations for the desulphurization of heating oil, coal and brown coal burned as fuel in private households. There should also be similar provisions for heavy heating oil,

   (d) a proposal in the form of a directive providing for a radical reduction of pollutants in motor vehicle exhaust gases from 1 January 1986 onwards;

   4. proposals for action programmes aimed at providing the technical and financial means to implement the objectives set out under points 1 and 2 above.

2. Calls on the Commission so to frame this major programme of measures to combat air pollution that emissions of the major components of air pollution are reduced in the European Communityby a factor of 2 within the next 5 years and again by a factor of 2 after a further 5 years;

3. Calls on the Commission in this connection to amend the directive on SO_2 and suspended particulates to meet the requirements set out in the preceding paragraph;

4. Urges the Commission to take advantage of the possibility of shortening the time-span within which these standards must be achieved by having recourse to a selective fuel use programme (in which relatively high-sulphur fuel is allocated to 'clean' installations and relatively low-sulphur fuel to installations in need of improvement;

5. Welcomes the Commission's proposal to tighten up the requirements of Directive 70/220/EEC on air pollution by gases from positive-ignition engines of motor vehicles, but once again urges the Commission to extend this directive to diesel engined of heavy vehicles;

6. Likewise urges the Commission in this connection to take steps to further:

   - the introduction of lead-free petrol as soon as possible,
   - the adoption of systems of catalytic reduction of exhaust gases,
   - the use of LPG,
   - the favouring and encouragement of public as opposed to private transport insofar as public transport produces less pollution;

7. Asks the Commission to draw up the action programmes referred to in paragraph 3, in collaboration where possible on a voluntary basis, with the professional groups listed in Annex I of the draft framework directive on air pollution of 15 April 1983 and to begin with an action programme geared to the energy industry;

8. Asks the Commission to bring order to the bewildering mass of specifications in force and to harmonize them in consultation with the Member States;

9. Calls on the Commission to give details in a separate note of how the desired programme of measures to combat air pollution can be financed and, in so doing, to give consideration to:

   - the 'polluter pays' principle,
   - the suggestion that a separate fund be set up, financed from levies on, say, emissions of SO_2, NO_x, NH_3 and heavy metals, to be used on the one hand to fund the programme to combat air pollution and on the other to bring pressure to bear on polluters to clean up their production processes, or to encourage the creation of similar funds,
   - a Community-level aid programme to support small and medium-sized undertakings and structurally weak regions in order to ensure that standards are uniformly applied and that there is no loss of jobs,
   - the extent to which existing Community financial instruments can individually or (in some cases) jointly play a stimulative role,
   - in particular the means available to the EAGGF to combat the problem of NH_3 in agriculture;
   - to what extent levies might help to bring about a speedier solution to the problem of older installations,

10. Requests the Commission to institute a European forest damage register;

11. Requests the Commission to promote a statistical survey or European air pollution which could form part of a European environment survey such as the European Parliament has called for repeatedly in the framework of the budget ,and to speed up the expansion of the number of measuring stations;

12. Requests the Council and Commission

(a) to urge those countries which have not yet ratified the 1979 Convention on long-range transboundary air pollution to do so, and

(b) in conjunction with the Scandinavian countries, to step up negotiations with the eastern European countries with a view to

(i) securing a reciprocal reduction in SO_2 emission levels,

(ii) incorporating in the Convention a reference to the reduction of NO_x emission levels;

13. Requests the Commission actively to coordinate scientific research into air pollution in the European Community in order to prevent duplication of effort and to ensure that the results are made available as rapidly as possible, and in so doing to consider above all research into alternative non-polluting energy sources, such as the production of H_2 with the aid of solar energy;

14. Calls on the Commission to state as quickly as possible what level of staffing and funding it requires so that the measures called for to combat air pollution can be implemented speedily and effectively;

15. Calls on the Council to make available the staff and financial resources required by the Commission in order to combat air pollution;

16. Instructs its President to forward this resolution to the Council and the Commission.

EXPLANATORY STATEMENT

I. ACID RAIN, ANALYSIS AND ORIGIN

1. The widely used term 'acid rain' is a collective concept. It covers a number of air pollutants generated in particular in combustion processes. The substances in question can also be emitted as a result of industrial processes or, in the case of ammonia, of (intensive) livestock rearing.

   The main components include oxides of sulphur and nitrogen, their acid derivatives, ammonia, heavy metals, carbon monoxide and photochemical oxidants.* The harmful effects of the various materials seem to be greatly intensified by their interaction.

2. Coal and oil contain anything from less than 1% to more than 5% sulphur depending on their origin.

   During the combustion of coal and oil some 95-98% of the sulphur is released (emitted) as sulphur dioxide (SO_2), and 1-2% as sulphur trioxide. The remainder combines with ash and fly ash particles.

   More important than the sulphur content of the fuel is the quantity of SO_2 emitted in relation to the quantity of energy generated (in gigajoules). Compared to bituminous coal or oil which have an equally high sulphur content, lignite - which is relatively low in sulphur - gives a relatively high SO_2 emission by virtue of its low calorific value.

3. Fossil fuels contain a quantity of chemically compounded nitrogen (N). The combustion fumes contain a very large amount of gaseous nitrogen. Particularly at very high temperatures this reacts with the oxygen in the combustion gases to produce nitrogen oxides (some 95% nitrogen monoxide (NO) and 5% nitrogen dioxide (NO_2)). NO is converted quite rapidly into NO_2 in the atmosphere.

4. These oxides react with the water in the atmosphere (steam, rain, fog, etc.) or with ground or surface water to produce the so-called 'acid' derivatives.

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* The problem of the increasing amount of carbon dioxide (CO_2) in the atmosphere, which is related to energy consumption and which is seen by various leading bodies as a fundamental threat, is not taken into account in this report.

(Sulphur trioxide and water, for instance, form sulphuric acid (H_2SO_4) and nitrogen dioxide and nitrogen trioxide and water, for instance, form nitric acid (HNO_3)). These substances, together with hydrochloric acid (HCl)(produced in the burning of plastics and coal with a high chlorine content) are responsible for the acid nature of the pollution.

Sea salt aerosol can also form HCl under the influence of free H^+. Ammonia (NH_4) is converted into nitric acid by nitrobacteria in the soil.

5. The sources of air pollution can be broken down by and large into:

(a) power stations and urban heating installations,
(b) traffic,
(c) industry,
(d) households and small users,
(e) agricultural undertakings,
(f) natural sources (e.g. volcanoes).

6. The degree of pollution caused by these different categories varies from country to country but it is difficult to obtain comparative figures. In Germany power stations are responsible for 56% of SO_2 pollution, traffic for 3%, industry for 28% and small consumers for 13%.

In the case of NO_x the figures for Germany are: power stations 31%, traffic 45%, industry 19% and small users 5%.

7. In the Netherlands road traffic is responsible for 5% of SO_2 pollution and 55% of nitrogen oxide emissions. Power stations and industry together cause 75% of SO_2 pollution and 25% of NO_x pollution.

In the UK power stations are responsible for around 61% of SO_2 pollution, traffic 2%, industry 28% and small users 3%. In the case of NO_x the figures are: power stations 46%, traffic 28%, industry 23% and small users 3%.

In Italy SO_2 emissions break down as follows: power stations 40%, industry 40% and domestic heating 20%.

From this we can conclude that power stations are the main source of SO_2 pollution and traffic the main source of NO_x pollution. Figures from other countries follow broadly the same pattern.

8. With conventional combustion techniques, incomplete combustion may produce considerable amounts of substances such as carbon monoxide (CO), aldehydes, hydrocarbons and rust.

The particles which are emitted as fly ash can be measured in thousands of millimetres and are mainly made up of iron, silicon, aluminium, magnesium, trace elements and carbon. The amount of fly ash liberated depends on the combustion temperature and the ash content of the fuel. In Germany fly ash emissions were reduced by around 60% between 1966 and 1978. The current level in Germany is 0.54 million tonnes per year.

Fluorides and selenium, for instance, may also be released in the form of gas or steam.

9. In the combustion of fossil fuels large quantities of highly toxic heavy metals are also emitted, such as lead, cadmium and mercury.

These heavy metals are often adsorbed into fly ash. 39% of the total emissions of cadmium in Germany comes from combustion installations.

Lead emissions in Germany amount to 4,600 tonnes per year, of which 70% comes from traffic and 20% from the steel industry. In terms of emission levels this is equivalent to 1.1 kg of lead per hectare per ten years in rural areas, rising to 7.3 kg of lead per hectare in built-up areas.

10. Photochemical oxidants (see also the report on photochemical pollution (Doc. 1-636/81)) (e.g. ozone) are generated by air pollution in certain climatological circumstances. The longer air pollution remains in the atmosphere the higher the content of photochemical oxidants. (The accelerated mortality of woodlands in Bavaria, far distant from the source of emissions, in the dry and sunny year 1976, is ascribed to a certain extent to the effect of photochemical oxidants and particularly ozone and PAN (peroxyacetylnitrate)).

11. Some pollution reaches the ground as a solution in rain (wet deposition) and some is deposited direct from the dry air on to surfaces of buildings and plants (dry deposition). When the dry deposition is moistened by, for instance, dew, the result can be very acidic solutions.

12. Sulphur and nitrogen compounds also occur in the atmosphere naturally as a result of biological processes.

The natural SO_2 concentration in the air should be 1-3 micrograms/m^3 whereas the present concentration in the air above Europe is in many cases ten times as much as this.

13. Ammonia emissions from intensive animal rearing as a cause of acid rain are a problem apart. These ammonia emissions are a result of the method of storing manure. Total ammonia (NH_3) emissions from animal manure in Europe are estimated at between 150,000 and 300,000 tonnes per year, equivalent to 25-50 kg/hectare per year.

Although initially this ammonia has a neutralizing effect on the acidity of the precipitation, the ammonium sulphate deposited on surfaces is ultimately converted through (bio)chemical processes to nitric and sulphuric acid and is an important factor in soil acidification.

14. The acidity (pH) of a solution is determined by a scientific formula based on the hydrogen-ion (H^+) concentration.

A pH value of 1 is very acidic (battery acid), pH 7 is neutral (distilled water) and pH 13 is very alkaline (lye).

Rain water is by nature mildly acidic (ph 5 or 6) due to the carbon dioxide absorbed in it. Due to the strong acids present in polluted air such as sulphuric acid and nitric acid, acidity of 4.5 is now quite normal in large parts of North America and Europe (approx. 13 times normal acidity).

There have however been examples of rain with an acidity of 2.5-3.0 (up to 1,000 times usual acidity).

Moreover, the acidity of rain water is not an indication of the total acid deposition. Ammonia, for instance, can make rain water less acid while in fact compounding its acidifying effect.

II. PAST, PRESENT AND FUTURE, EXAMPLES

15. The effects of air pollution on health and the environment were noted, on a geographically limited scale, only a short time after the Industrial Revolution. As early as 1863 the Clean Air Act was passed in England to reduce air pollution in the heavily industrialized areas.

The unilateral policy of distribution and dilution, and the policy of high chimney stacks, has resulted in an even spread of pollution throughout Europe and North America.

16. At present, damage to materials, crops and public health amounts, according to various estimates, to several percentage points of the gross national product of the EEC countries. The OECD estimate is between 3 and 5% of the gross national product or 60 to 80,000 million ECU per year! And this does not even include every cause of damage.

17. Generally speaking, the policies in the EEC countries are based on stabilization of present air pollution levels or a slight reduction by 1985*. NO_x pollution is expected to increase in a number of countries.

Extrapolation of present data suggests therefore that this will result in progressive irreparable soil damage over large areas.

18. Examples

As your rapporteur believes that it is impossible in this report to give a full or even comprehensive picture of the actual damage a number of typical examples are given instead. These will perhaps give an impression of the truly vast scale of the damage to the economy caused by air pollution.

(a) In Germany in September 1982 560,000 hectares of woodland were designated a total damage area, i.e. total loss of productivity is expected. This damage is to be found in all the Länder but is most pronounced in Bavaria (160,000 hectares), Baden-Wurttemberg (130,000 hectares) and North Rhine-Westphalia (more than 70,000 hectares).

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* Germany is the only EEC Member State where there are signs of an improvement in this situation; the government has now passed a law lowering permissible SO_2 emissions from factories and power stations from 650 mg to 400 mg/m^3 of waste gas.

Even in the Black Forest there are fears of an imminent breakdown of the forestry sector because of the extremely rapid rate at which the damage is spreading.

According to a survey by the German Forestry Association, damage symptoms are apparent in 2 million hectares of pine forest (half of the total German area of pine forest). The related loss of production will bring an estimated loss of 47,000 jobs in the German forestry and wood processing industry*. Damage to Cologne cathedral alone costs 6 million DM a year. The historic mining museum in Dortmund loses 4% of its weight every year.

(b) In the Netherlands a number of woods have suffered comparable damage. The pictures and ornaments on the exterior of the 458-year-old St. Janskerk in 's-Hertogenbosch are so eroded as to be unrecognizable. This historic building in under permanent restoration. Damage to historic buildings is estimated at 30 million guilders per year.

(c) In Luxembourg the silver spruce died out 13 years ago. A falling-off of new growth was observed as long ago as 1958, ten years earlier.

(d) The devastated woodlands in the German Democratic Republic, in the Erzgebirge, have upset the water economy on the northern slopes and this is having very serious consequences for the lower lying agricultural areas.

(e) The heavily wooded mountains between Poland and Czechoslovakia are seriously affected (in the Riesengebirge for instance 32,000 hectares of fine spruce).

In Poland more than 400,000 hectares of woodland have been affected.

The historic buildings of the Polish city of Cracow have to be completely restored every 5 years.

In certain parts of Poland there is a 40 km/h maximum speed limit on trains because of corrosion of the rails by acid rain.

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* The forestry and wood processing industry in Germany provides 800,000 jobs and produces goods to the value of some 100,000 million DM per year.

(f) Approximately 20% of the 100,000 lakes in Sweden are affected by acid rain. 4,000 lakes are biologically dead. In southern Norway the situation is even more serious (if this is possible): 80% of the lakes there are affected.

(g) 2,000-4,000 lakes in Ontario (Canada) and 1,800 lakes in Quebec, more than 10% of the large fresh-water lakes in New England, in the Oldivouslack Mountains and the Adirondack Mountains (USA), no longer contain any fish.

(h) Research in the USA and England has shown that the corrosion speed of nickel is 1.8 μ/year in Newark - with an urban industrial atmosphere - and 6 μ/year in the heavily polluted atmosphere of Birmingham. These figures must be compared with the low corrosion speed of 0.25 μ/year encountered in country areas and above the sea. (1 μ = 0.001 mm).

(i) In London every large historic building is suffering from damage from acid rain. In some places more than an inch of the Portland stone used to build St. Paul's Cathedral, on which work started in 1675, has been eaten away. The north-west tower was recently restored at a cost of £300,000.

(j) In Athens (Greece) the Parthenon is one of the buildings seriously damaged. 80 million guilders have been earmarked for restoration work on it.

(k) In Rome (Italy) the Colosseum is one of the buildings seriously damaged.

III. HARMFUL EFFECTS

19. Sulphur dioxide, nitrogen oxides and their derivatives seem to attack a very wide spectrum of materials. These are materials which are in many cases not easily replaceable components of the main products of our industrial society.

The life of materials such as metals, calciferous stone, concrete and cement, protective paints and lacquers, paper and textiles is considerably reduced.

20. In the case of metals corrosion speed as a result of natural elements (climate, etc.) is approximately of the same order throughout the whole temperate climate zone. It can thus be assumed that geographical differences in corrosion speeds in the European climate are caused by differences in air pollution (sulphur and nitrogen compounds, HCl, etc.). Sulphate particulates help to corrode metals by:

- direct chemical reaction or reaction with the protective anti-corrosion coating (which would under normal circumstances protect the metal from further corrosion),
- functioning as a condensation point for dampness on the surface,
- functioning as an adsorption point for other pollutants.

There are substantial indications that H_2S and NO_x cause considerable pollution to the interiors of buildings and in particular the corrosion of electrical installations and contact materials such as precious electronic apparatus. It has recently been shown in laboratory studies that COS (carbonyl sulphide) causes copper corrosion to the same extent as H_2S. Laboratory tests have not shown any clear link between nitrogen oxides and nitrates and the corrosion of galvanized steel. But the nitrogen derivatives do seem to play an important part in synergistic action together with sulphur products. The speed of corrosion is then considerably accelerated.

21. Calciferous building materials such as sandstone, limestone, marble, cement and concrete are attacked by SO_x. Whenever sulphurous materials are adsorbed on the surface a series of reactions begins with the formation of gypsum (calcium sulphate) as the end product. The gypsum which is more soluble than lime (calcium carbonate) is then washed away by the rain. More serious damage is caused when the gypsum forms in porous materials under the surface. Calcium sulphate (gypsum) occupies a larger space than calcium carbonate (lime), this leads to fissures and the stonework often starts crumbling away. This can be dangerous in particular for pre-stressed concrete structures.

22. The influence of air pollution on concrete is as yet little documented. Calcium aluminate (which also occurs in cement made from fly ash) is converted in the presence of sulphur compounds into ettringite, the greater volume of which causes fissures in the concrete. The expansion caused by accelerated corrosion of concrete reinforcement steel also causes cracking (rust also has a larger volume than iron).

23. Paints and coatings are affected by SO_x and NO_x. Moreover, paints adhere less successfully to polluted surfaces. This can halve their lives.

It has been shown that NO_2 is adsorbed to a great extent by oil-based paints. Certain metals such as bronze, zinc, lead, etc. are traditionally left uncoated since the corrosion layer of these metals protects them against further damage.

24. Textile fibres are attacked by SO_2 and NO_x (inside buildings). Cotton and all cellulose fibres lose their tensile strength.

Synthetic polyamide fibres display a similar disintegration process to leather. Leather disintegrates to a red powder. Paper is attacked by SO_2 and NO_2. The fibres of the paper lose their strength just like cotton fibres, until the paper disintegrates. Considerable damage has occurred in some libraries and archives in the centre of heavily polluted towns for this reason. In the Netherlands this damage is estimated at 620 million guilders.

25. Some of these substances which cause air pollution provide food for all kinds of autotrophic* organisms. This problem has not yet been studied in all its aspects. It is known that Thiobacilli which derive their energy from the oxidation of H_2S and SO_2 and also Ferrobacilli which derive their energy from the oxidation of ferrite in rocks flourish on pollutants deposited on a variety of different surfaces. The organic and inorganic acids formed by these bacteria attack the material.

There are also bacteria which derive their energy from the nitrogen cycle. The ammonia and nitric acid thus formed can attack works of art and paintings in particular. (Ammonia turns the paint Malachite green to blue). Ammonium sulphate cristallizing in the pores of a material causes it to burst. The autotrophic bacteria mentioned above appear to constitute the start of a food chain (ecological succession). This can lead to massive growths on polluted surfaces of Fumycetes and Actinomycetes which penetrate the underlying material with their microscopic mould filaments and attack it rapidly from inside.

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* An organism which feeds itself from inorganic sources.

26. Acid rain can harm human health both directly through inhalation of the pollutant gases, aerosols and particulates (particularly sulphates) and indirectly by the introduction of toxic metals into food and drinking water.

27. Research is mainly directed towards the causes of respiratory diseases, and in particular bronchitis, covering a range of symptoms varying from persistent coughing or profuse expectoration to irreversible impairment of the lung function.

Experiments in which test animals and humans were exposed to SO_2 produced much less harmful effects for certain SO_2 concentrations than needed to justify statistical research on practical situations. This fact has long concealed the seriousness of the problem.

28. The SO_2 concentration during, for instance the notorious London fogs in the 50s should, according to laboratory findings, have produced a much lower death rate than was in fact the case. It is probable that rust particulates played a large role in this. In practice, the synergistic action of other air pollutants (in this case rust particulates) is very important, as is the long-term effect of low concentrations and the greater sensitivity of certain categories of the population.

Individuals exposed to an atmosphere with a PAN concentration of 0.3 ppm (parts per million) for 5 minutes display a rapid increase in oxygen consumption. Exposure to a PAN concentration of 0.5 ppm for 5-10 minutes causes eye irritation.

29. Only fragmentary research has been carried out into the long-term effects on health of acid air pollution. However, two extensive research projects involving children in the UK established variations in the pattern of respiratory diseases between urban and rural areas. These differences were ascribed to differences in the level of air pollution.

30. A Dutch research project into chronic non-specific respiratory infections is bringing evidence of significant increases in the number and seriousness of symptoms in the presence of greater air pollution. This long-term study has shown that over a period of 10 years the lung function deteriorates one-and-a-half times more rapidly in an industrialized environment than in a rural environment even though the concentrations during that period did not exceed the prescribed health standards in either area.

31. The World Health Organization's 1979 report stated that average concentrations over a year of approx. 100 micrograms SO_2/m^3 and 100 micrograms rust/m^3 caused changes in the lung functions in categories of the population (adults and children).

The WHO suggests as an admissible ceiling an average concentration over the year of 40 micrograms/m^3. However this criterion is not applied everywhere. The Dutch SO_2 policy outline is based on an admissible upper limit of 75 micrograms/m^3 for the median of the values averaged out over 24 hours. The EEC standard (80-120 micrograms/m^3) is also well above the WHO level.

32. The following conclusions are generally accepted:

(a) SO_2 and its derivatives can damage health and even cause more deaths;

(b) the presence of SO_2 together with dust and above all rust particulates is more damaging than could be assumed from the combination of the separate influences of these two components. The combination of these two materials operates synergistically and they strengthen each other's effect;

(c) sulphuric acid and perhaps even certain sulphates are more detrimental to health than SO_2.

(d) at all events bronchitic complaints, asthma attacks and increasing respiratory difficulties are influenced by SO_2, sulphuric acid and sulphates;

(e) nitrogen oxides and photochemical oxidants also cause respiratory infections (see report on photochemical oxidants - Doc. 1-636/81*);

(f) although there is agreement on the above points there is no general agreement on the concentrations at which certain developments take place.

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* OJ No. C 125 of 17.5.1982, p. 163

33. The serious damage to 560,000 hectares of woodland in the Federal Republic of Germany has most probably been caused by soil deterioration. Soil deterioration is caused by the following process:

(a) The acids from rain water absorb the fruitful alkaline minerals such as potassium, calcium and magnesium and they are then leached out of the soil with the groundwater. As a result trees begin to show signs of magnesium deficiency. Once these neutralizing minerals are used up the soil suddenly becomes very acidic.

Virtually all rain water passes through the soil before it reaches watercourses and seas. If the soil no longer has any neutralizing effect, the surface water rapidly becomes acidic (Scandinavia, Central Europe).

(b) Once the soil has finally become acidic metals such as aluminium dissolve and they are extremely toxic in their dissolved state. As a result trees in the affected woods often suffer from root rotting and lakes become biologically dead. Various forms of bark necrosis are also linked to aluminium poisoning.

(c) Simple lime treatment does not restore the soil. Several minerals are leached away by the acid and attempts to restore the pH value of the soil simply by adding minerals such as lime cannot reverse the process of soil deterioration. Lime treatment in seriously affected woodlands often has the effect of speeding up the decay, because adding lime speeds up the mineralisation of the layer in contact with the lime which after some time leads to magnesium and potassium deficiency.

(d) One factor which makes if difficult to determine damage in practice is the fact that damage caused by direct reaction with substances in the atmosphere cannot always be distinguished from indirect reaction through the soil or groundwater. Soil has only a limited number of ways to react to the innumerable forms of 'environmental stress'.

(e) Up to now those areas where the damage caused by air pollution has been investigated have always been considered to be the only ones seriously affected. Although damage in countries such as France and Belgium is not 'officially' investigated, experts report evidence of damage in those countries.

34. Heavy metals represent a separate little-researched factor in air pollution. A project by the University of Göttingen has shown that these toxic metals accumulate in the top layer of the soil. Here they represent a threat to life in the soil and plants.

If the environment is acidic this harmful effect is strengthened as the heavy metals referred to above and the (heavy) metals which occur naturally in the soil in non-toxic chemical compounds then become very mobile. Needles, leaves and fibrous roots of trees in woodland affected in Söllingen displayed a greatly increased content of heavy metals. Absorption of heavy metals by plants, either from the soil or directly from the atmosphere, is between 3 and 10 times greater in acidified soil.

As a result of the fact that these metals usually accumulate in the food chain the game, fish and mushrooms in some areas of Central Europe and Canada are no longer fit for consumption, since eating them could affect the central nervous system.

In compounds with dust and suspended particulates (e.g. fly ash) the heavy metals can penetrate deep into the lung tissue and therefore represent a threat to public health.

There is a marked correlation between the level of air pollution and the cancer mortality rate in all the regions of the EEC.

IV. COST/BENEFIT

35. Recently various institutes have made very cautious estimates of the damage caused by acid air pollution to certain types of objects. The problem encountered in all these studies is that the effects of various different components of air pollution are difficult to distinguish from each other.

Another difficulty is that total damage cannot be precisely quantified in terms of money. There are various reasons for this:

- only a limited amount of material has been subject to dosage effect studies and always under laboratory conditions;

- in the case of a large number of objects the harm is apparent but almost impossible to express in financial terms. Often the objects concerned are cultural assets and nature reserves which are hardly part of the normal economic cycle.

36. The economic damage caused in the EEC by soil deterioration as a result of acid rain has as far as your rapporteur can ascertain not yet been estimated in any research project.

In terms of a permanent loss of this very precious means of production and of the collapse of the forestry sector and related processing industries, soil deterioration is probably responsible for the bulk of the damage at national economic level due to air pollution.

37. One of the most authoritative studies of the costs and benefits of the combating of acid air pollution is the OECD 1979 study. This study also refers to the situation in the EEC countries.

The study starts with a zero situation with no measures between 1974 and 1985 for the limitation of emissions and goes on to examine various alternative situations in which to an increasing extent measures are taken to limit emissions during this period. According to the calculations contained in this report these alternatives can lead to changes in the amount of SO_2 emitted varying from an increase of 21% to a reduction of 37%.

The damage (expressed in dollars in 1976 values) is estimated on the basis of:

- production losses in the case of agricultural crops,
- corrosion of zinc and paint coatings,
- extra costs of public health services,
- damage to fresh water fisheries.

The calculations contained in the report show that for each situation the cost of reducing emissions (varying from $5 to $12 per capita of the population) are virtually the same as the amount to be gained from reducing damage.

38. There is therefore - from a macro-economic viewpoint - no reason at all not to put into practice a scenario in which emissions are reduced on the basis

of the best technical means available. This is all the more so since the OCED estimate does not contain figures for damage to buildings, paper, textiles, electrical apparatus, other metals than galvanized iron, woods, etc. This means in fact that the social benefits of anti-pollution measures are considerablygreater than the social costs.

39. In Germany certain interest groups have made a global estimate of damage based on the following reasoning. German woodland, which covers 7.5 million hectares, represents a capital asset of 150 to 200,000 million DM plus a related economic productivity in the wood processing industry of some 100,000 million DM per year. The loss of the productivity of 560,000 hectares or a general fall in productivity of around 7% therefore represents a direct capital loss of some 10,000 million DM and an estimated annual financial loss for the wood processing industry of 400 million DM.

40. In the Netherlands, the Institute for Environmental Problems estimated damage for 1970 in five categories:

- health damage (bronchial infections)
- loss of residential amenity
- damage of materials (zinc-coated steel, limestone, paper and textiles)
- damage to commercial crops
- damage to agricultural domestic animals.

The estimate totalled 2,600 million guilders (1970) 2.26% of the national income.

41. In the UK the damage caused by SO_2 alone to agriculture and horticulture is put by some at £100 million per year.

42. According to the technical reports presented at the Conference on Acid Rain in 1982 in Stockholm the cost of flue gas desulphurization could amount to 15% of the operating and capital costs of stations, depending on the nature and size of the installation and the sulphur content of the fuel. This maximum amount also includes the costs of processing waste.

43. However limited these damage analyses may be they do, in your rapporteur's opinion, show quite clearly that the costs of flue gas desulphurization only amount to a fraction of the damage set out above. This conclusion carries more conviction as more damage is brought to light and flue gas desulphurization becomes cheaper.

44. Generalizing flue gas desulphurization may lead to roughly a 5% increase in the price of electricity to the consumer. This price increase falls within the normal range of fluctuation of energy prices and therefore should not meet with overwhelming socio-economic resistance.

V. POSSIBLE MEASURES AGAINST SO_x AND NO_x EMISSIONS

45. Given the present state of the art it is possible to cut down emissions of the most polluting substances by 70-95%. The necessary technology exists and 80-90% desulphurization is financially feasible. The obstacles tend to be in the field of political decisions and legal and legislative possibilities.

In most anti-pollution techniques the cost of removing the last 5% of the pollution is disproportionately high. For financial reasons the purification can thus probably be best undertaken in stages via fuel desulphurization, clean combustion techniques and flue-gas purification to give a cost-effective residual emission level.

46. Fuel economy through technical innovation can also contribute substantially to the reduction of air pollution. This is possible in particular in transport (engines), power stations (co-generation of power and heat) and households (active and passive solar energy). An associated advantage which is also extremely important is the reduction in CO emissions.

47. So far the method universally used except in Japan, has been dilution (the building of high chimney stacks). This does not in any way cut down the emission. It simply avoids acute regional levels of damage. This is however the reason why in the 70s the accumulated effects began to take on catastrophic dimensions over the whole northern hemisphere.

Dilution as a method of combating high SO_2 concentrations is thus not even a temporary solution and never has been, a fact which was also recognized by the Second Stockholm Conference in 1982.

48. Fuel desulphurization can also contribute to the reduction of pollution. The cost of desulphurizing oil amounts to approximately 20 guilders to 50 guilders per tonne (1978 price levels).

The sulphur content of coal can be reduced by 15-30% at a price of approx. $1 to $20 per tonne by crushing and washing. Coal is often washed already at the pithead to reduce the ash content.

Effective chemical cleansing methods are not attractive in economic terms. On the one hand 30-50% of the energy content is lost and on the other chemical cleansing also produces its own consequences for the environment.

49. NO_x can be reduced by using combustion techniques with lower combustion temperatures and proper adjustment of the air supply. These techniques often imply phased combustion (i.e. on its way through the furnace the fuel is repeatedly dosed with the exact amount of combustion air required). A feature of fluidized bed combustion in particular is the low NO_x formation because temperatures are uniform and low.

The success of measures to control the combustion process in order to reduce the formation of nitrogen oxides is also in part determined by the characteristics of the fuel (e.g. the percentage of aromatically or aliphatically compounded nitrogen in the fuel). Applying clean combustion techniques to the types of bituminous coal currently used in Germany can give NO_x levels of 150-300 ppm in flue gases.

50. In the fluidized bed combustion process fine particles of coal or oil float or whirl in an upwards stream of air and very intensive combustion is thus obtained. As the coal is introduced in a mixture with grains of lime a large part of the sulphur (up to 80%) is converted into gypsum. Due to the low combustion temperatures the formation of NO_x in fluidized bed combustion is also limited without the need for any further measures to approximately 50% of the amount formed in other combustion techniques. Fluidized bed combustion is also the only method which uses grades of coal which formerly were unsuitable for use in traditional burners because of their low calorific value.

Moreover, it is now also possible to make use of coal which has been tipped on to spoil heaps and defaced the landscape since mining began.

Although much still remains to be done to develop and improve this technique it can nevertheless be considered as the best practical means.

51. Where supplies go to several smaller users for whom it is not feasible to install purification plants coal gasification may be a solution although still a fairly expensive one.

Coal gasification produces a combustible gas from which the sulphur compounds can be removed almost entirely.

At the present time there are more than 100-200 coal gasification plants in operation, although most of these are for the production of NH_3 synthetic gas.

52. Flue gas desulphurization has been used since 1929*.

This method is widely used in Japan where since 1977 about 1,000 flue gas desulphurization units have been in operation based on 15 different processes. Most of these processes are based, by and large, on scrubbing with wet solutions or lye. Lime or calcium carbonate is usually used as a reagent and calcium sulphite is formed in reaction with SO_2. In the so-called double alkali (lye) methods a sodium sulphite solution is used as the scrubber medium and later treated with lime or calcium carbonate in order to recover the sodium sulphite. These processes are up to 95% efficient.

A process in which suspended particulates are captured and SO_2 removed is the spray-drying process. A watery suspension of lime or limestone is sprayed into the gas stream. The hot combustion gases cause the water to evaporate and the dry salts are usually retained in a filter.

This process is up to 80% efficient. It is a relatively cheap solution if low-sulphur fuel is used.

As regards raw materials and the problem of waste processes during which acid products are neutralized by the fly ash are also very promising.

The quantity of heavy metals in emissions can also be considerably reduced by flue-gas desulphurization, coal desulphurization (and the use of dust filters).

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* The Battersea Power Station in London