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cc FCO DTI Cab. Office

10 DOWNING STREET

From the Private Secretary

9 December 1985

ACID RAIN

I enclose a copy of a letter to the Prime Minister from the Norwegian Prime Minister, following up their conversation on 27 November about acid rain, and submitting a summary of the scientific evidence for the proposition that emission from United Kingdom plants (among others) are responsible for water acidification in Norwegian lakes and threaten damage to Norwegian forests.

I should be grateful for a draft reply covering both the scientific and the political arguments in support of our position.

I am copying this letter and enclosure to Colin Budd (Foreign and Commonwealth Office), John Mogg (Department of Trade and Industry) and Sir Robin Nicholson (Cabinet Office).

(CHARLES POWELL)

Robin Young, Esq.,
Department of the Environment.

JB

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PRIME MINISTER'S
PERSONAL MESSAGE
SERIAL No. T225A/85

THE ROYAL NORWEGIAN GOVERNMENT

THE PRIME MINISTER

5 December 1985

Prime Minister Margaret Thatcher
10 Downing Street
London

Dear Mrs. Prime Minister,

I much enjoyed our wide-ranging conversation in your office in the House of Commons last week, and I am very grateful that you were able to find the time to meet despite an important parliamentary debate. I would like to remind you that during our conversation on 27 November, you requested material documenting the experimental scientific evidence of "what the problem is" as regards acid rain, in particular as it affects the relationship between the UK and Norway. I promised to forward such material directly to you, and I am now happy to do so. The enclosed overview gives a summary of the present state of knowledge in this respect, and I know that your background in science will make the material all the more pertinent to you personally.

I would like to outline briefly what the Norwegian Government believes to be the most salient points:

* There is international consensus in the scientific community that emissions of air pollutants such as sulphur and nitrogen oxides are causing widespread acidification of precipitation over large areas of Europe and North America.

* The OECD Long Range Transport Project (1972-77), and the current ECE programme (EMEP) have established beyond doubt that emitted air pollutants such as sulphur are transported over large distances (thousands of kilometers) in the atmosphere. In this context source-receptor relationships have been established showing the deposition of sulphur in each European country due to emissions in any other country.

* Between 1978 and 1982 the average annual deposition of sulphur in Norway due to UK sources was 48,000 tonnes. The deposition due to UK sources represented about 15% of the total annual average deposition, which was 310,000 tonnes. In the south of Norway the average annual deposition due to UK sources over the same period was much higher, up to 30%. The figures have not changed substantially since this 4-year period. Comparisons with contributions from sources in other countries show that the UK is the greatest single contributor to the deposition in Norway.

* Acidification of water has led to dramatic reductions and loss of fish populations in southern Norway, southern Sweden, Scotland, eastern Canada and the northeastern US. Today, lakes in more than 13,000 km^2 of south Norway are practically devoid of fish, and in an additional area of 20,000 km^2 the fish stocks have been considerably reduced. There is no doubt that the fish loss is caused by acid, aluminium-rich water. There is little solid evidence of water acidification due to other factors than acid deposition, e.g. land use changes.

* Changes in soil acidity are also causing concern. One study in Rondane (a mountainous area in Norway) over a 40-year period showed changes of between 0.3 and 0.8 pH units in the different soil layers, e.g. from pH 5.1 to 4.5.

* The recent and comprehensive forest damage in Central Europe is well-documented. In 1984, 50% of forest stands in the Federal Republic of Germany were reported to be damaged. Although the evidence is not yet conclusive, most scientists agree that air pollution is, at the least, a significant contributory factor. Although no damage is yet evident in Norway, we are deeply alarmed about the threat posed to our own forests by the cumulative effects of extensive transboundary air pollution.

* Damage to materials (corrosion) due to air pollution is extremely widespread and equally well-documented.

* It has been questioned whether a reduction in emissions will result in a corresponding decrease in deposition. The environmental benefit of such reductions has also been doubted. An increasing number of theoretical calculations and actual observations both in the UK and other countries indicate strongly, however, that, for example, a 30% reduction in emissions will result in a proportionate reduction in deposition, even if not exactly by 30% in all areas. Furthermore, comparable calculations and observations show that reduced emissions will improve conditions in acidified streams and lakes. The best example of this is provided by studies around Sudbury, Ontario, but similar studies have also been carried out in Sweden and the UK.

For further details, I refer you to the enclosed overview and the reports listed therein.

Allow me once more to urge you to make an extra effort to control this pollution which harms the environment for present and future generations. I shall be happy to remain in contact with you on this very important question.

With best personal wishes
Yours sincerely,

Kåre Willoch

09 XII AM 8 5

10, DOWNING STREET,
WHITEHALL S.W.1

PLEASE RETURN THIS
DOCUMENT WITH DRAFT.

With the Private Secretary's

Compliments

The Acid Rain Problem:

An Overview

Ministry of Environment

Oslo, December 1985

MINISTRY OF ENVIRONMENT, Oslo   December 1985

The Acid Rain Problem: An Overview

Introduction

Only a few decades ago, air pollution was largely considered a local problem which could be solved by tall stacks in order to reduce ground level concentrations. Towards the end of the 1960s, however, this situation was disturbed by the observation that serious acidification of the precipitation was taking place over large areas of Europe, including areas far away from the major industrial areas. Since then, long range transport of air pollutants and the ecological effects of acid rain have been studied in a number of national and international research programmes. Although there are still gaps in our knowledge, substantial information is now available on emissions of air pollutants, transport and transformation processes in the atmosphere, the deposition rates on the earth's surface and on the ecological impact.

The major air pollutants causing acidification are sulphur and nitrogen oxides. Other important pollutants of concern on a regional scale are ozone and various toxic substances (heavy metals and organic micropollutants).

The main source of sulphur and nitrogen oxides is the combustion of fossil fuels (oil and coal) for heat and electricity production, and transportation vehicles.

Precipitation chemistry data series indicate that the sulphur in precipitation increased in many parts of Europe from the late 1950s to the late 1960s. Since then, the sulphur content has leveled off and even decreased somewhat, at least in Scandinavia. The content of nitrate in precipitation showed an even more marked increase up to the early 1970s. Since then little further increase is in evidence.

Large scale formation and transport of ozone and other photochemical oxidants have not been studied to the same extent as acid deposition. Available information, however, shows that ground level ozone is an environmental problem of international dimensions. As an example, in southern Scandinavia ozone concentrations above accepted air quality standards, and of the same magnitude as in Central Europe, are being occasionally recorded during episodes of long range origin.

The concern about ground level ozone as an air pollutant is significant in connection with acidification for several reasons; because ozone and other photo-oxidants are produced from hydrocarbons and nitrogen oxides emissions, contributing also to acid precipitation, and because ozone may increase the oxidation rate of sulphur and nitrogen oxides to sulphuric and nitric acids. Moreover, ozone together with sulphur dioxide and acid precipitation probably play an important role in the recent forest damage in Europe.

Mathematical models have been widely used to quantify the long range transport of sulphur compounds in Europe. In this way, "source-receptor" relationships are worked out, for example, within the UN ECE "Co-operative programme for monitoring and evaluation of long range transmission of air pollutants in Europe", estimating the deposition of sulphur in each European country due to emissions in any other country.

Emissions in the UK have been considerably reduced in recent years, but the UK annual emissions are still at a very high level (1984: 1.77 million tonnes of sulphur). Over a four year period starting in October 1978 it has been estimated that the average annual deposition in Norway due to UK sources was 48,000 tonnes of sulphur. The total annual deposition of sulphur in Norway during this same period was 310,000 tonnes, which means that the UK contribution was approximately 15 % (for the whole of Norway; up to 30 % in the South). Comparison with contributions from sources in other countries show in addition that the UK is the greatest single contributor to the deposition in the most affected areas in Norway. The figures have not changed substantially since the period cited.

It has been questioned whether a reduction in emissions will give an equally large decrease in deposition. This is often referred to as the non-linearity (or better non-proportionality) problem. Of course, if the sulphur emissions are reduced everywhere in Europe by say 30 %, the deposition will not decrease by exactly this percentage in all areas. However, both theoretical calculations and observations indicate strongly that deviations from proportionality will not be of great practical significance except perhaps close to the emission sources. This seems also to be the opinion of most atmospheric scientists in the UK.

Acidification of soil and water

The effects on soil and water depend not only on the deposited amounts of acidity, ammonium, sulphate, nitrate and other compounds, but also on characteristics of the area, in particular bedrock geology and the nature of the overburden. The most well-known areas susceptible to water acidification are those with shallow overburden and quartz-bearing bedrock, e.g. granite and gneisses. Such conditions are found in large parts of Scandinavia and Canada where recent acidification has clearly occurred. Smaller regions, apparently hit by the same problem, are found in many European countries (e.g. Scotland) and in the USA (e.g. Adirondack Mountains, NY.).

Three mechanisms are possible for the acidification of surface waters by acid precipitation, viz.

- direct input to the water surface
- increase in concentrations of mobile anions (e.g. sulphate and nitrate)
- acidification of the soil, which in turn leads to water acidification

In general, the three mechanisms work in combination. The second mechanism seems to be of greatest importance in many areas. Anions (particularly sulphate, but also nitrate and chloride) play an important role as vehicles for transport of cations. Since charge balance must be maintained as the ions pass through the system, the mobile anions must be accompanied by cations in equivalent amounts. In acid soils a significant fraction of the anions is balanced by hydronium (H^+) ions and aluminium (Al) species. High atmospheric deposition of sulphate (and nitrate) will therefore lead to water acidification and high Al concentrations.

Soil acidification may result from other factors than acid deposition alone, e.g. afforestation. It seems likely that the main effect of afforestation is an increased deposition due to a more effective "filtering" of air pollutants. Otherwise there is little solid evidence for water acidification due to land use changes.

Evidence for recent acidification

It is not easy to quantify the recent acidification in various areas. Comparison of old and recent measurements is hampered by uncertainties in older data, and often by insufficient detail in the description of methods used. Nevertheless, surface water acidification can in some cases be demonstrated by direct comparison of pH values. Loss of acid neutralizing capacity has been observed in groundwater in some areas.

Acidification of surface water has also been demonstrated by studying lake sediment cores, in particular the species of diatoms found. In areas susceptible to acidification, the frequency of acid-sensitive species has been strongly reduced in recent decades, as evidenced in many studies both in Norway, Sweden, North-east U.S.A. and the U.K. This shift in acidification rate is most dramatic compared to the slow long-term acidification caused by natural factors.

Due to the heterogeneity of soils, changes in soil acidity due to acid deposition are more difficult to quantify than those in water chemistry. Effects of deposition on soils are observed close to large point sources, such as the smelters in Sudbury (Ontario). Studies in central Europe show soil acidification in recent decades, probably partly due to acid deposition. A recent, reliable comparison with measurements from 1927 showed considerable acidification in all soil horizons at a site in southwestern Sweden. A study in Rondane (a mountainous area in central-eastern Norway) gave similar results. According to this study, changes in this area over a 40 year period have amounted to between 0.3 and 0.8 pH units in the different soil layers, e.g. from 5.1 to 4.5. Apparently there were no significant changes in the vegetation.

Biological effects

Water acidification affects the biota at all trophic levels. Not only the acidity *per se* causes damage. The increased acidity is accompanied by increased aluminium concentrations causing additional harm. The most dramatic effect is the reduction and loss of fish populations which cannot be explained by fish disease, overfishing or local pollution. The clearest evidence for decline in fish populations or disappearance of fish species comes from southern Norway, south and west Sweden, Scotland, parts of Ontario and Nova Scotia (Canada) and the Adirondack Mountains (USA). In southern Scandinavia thousands of lakes have become barren. The decline in trout populations in lakes in southernmost Norway is known in considerable detail. Although occasional fish kills, probably caused by acidic water, have been reported since before 1900 in this area, the most dramatic and widespread decline has occurred after 1950.

Today, lakes in more than 13,000km^2 of South Norway are practically devoid of fish, and at least in an additional 20,000 km^2 the fish stocks are reduced. There is ample field and experimental evidence that the fish loss is caused by acid, aluminium-rich water.

Relationship between deposition and effects

Although it is clear that decreased deposition will improve the water quality in affected areas, the quantitative relationships are not known in detail.

Both observations and simulation models based on the best knowledge of the important processes show that reduced emissions will improve the conditions in acidified streams and lakes. There are indications of this in Sweden and in the UK. The best example is, however, provided by studies around Sudbury, Ontario. Here the emissions have decreased dramatically in recent years. Both chemical and biological studies in the area show considerable improvements.

Forest damage

Reports on increasing direct damage to forests by air pollutants accumulated during the 1970s, and the local damage around smelters or other emitting industries started to become a regional problem, particularly where fuels rich in sulphur were used on a large scale. However, as late as 1980, there was no consensus on whether the increasing air pollution really threatened forest growth and vigour over whole regions. Very soon the situation changed drastically. Widespread tree damage including dieback of trees was observed in the Federal Republic of Germany on a rapidly increasing scale in the early 1980s and soon also in many other European countries. In 1983, 34 per cent of forest stands in the Federal Republic of Germany were reported to contain damaged trees. In 1984, the corresponding figure was 50 per cent, including the lowest damage class. (If this is excluded, the percentage is 17). It is estimated that the European forest decline now encompasses more than 7 million hectars. The geographical extent coincides in general with areas having high concentrations of air pollutants.

Signs of a similar "forest decline" were also observed in red spruce in eastern North America. The damage often occurred in areas relatively far away from emitting industries. The first trees to be affected in Europe were spruce and silver fir, but soon damage was observed in other species such as Scots pine, beach and oak.

There is as yet no full agreement on the precise causes of the damage, which most probably are complex. Most hypotheses include air pollution as either the cause or a main contributing factor to the "forest decline". There are strong indications that without air pollution and its wide dispersion the recent forest damage would not have occurred in its present form and extent.

The various explanations suggested are not mutually exclusive, and include cell damage by ozone and sulphur dioxide, direct damage by acid fog droplets, and indirect damage through soil acidification. There is also a general agreement that climatic stress, in particular drought, can play a role in the development of damage symptoms.

Clearly, Norwegian forests do not suffer from acute and widespread damage like in other parts of Europe, but the conditions of forests are followed closely, particularly in view of the recent observations of ongoing soil acidification.

Damage to materials

Several air pollutants increase the decay rate of many materials used in buildings and other constructions, including historical and cultural monuments. A major part of the damage to materials is due to the concentrations of sulphur dioxide in urban areas. This has been studied in several countries and the increased corrosion rate due to sulphur dioxide can be quantified reasonably well for many materials. The effect of acid rain on materials has been less studied. It has been shown, however, that the deposition of acid compounds to exposed materials may enhance the corrosion. In addition, the acidification of soil and water may increase the corrosion rate for underground constructions.

Attention has also repeatedly been drawn to the effects of acidifying depositions on the more than 100,000 stained glass objects in Europe, many of medieval age. Documentary records show that these objects were generally in good condition up to the turn of the century; however in the last 30 years, the deterioration process has apparently accelerated to the extent that total loss is expected within a few decades if no remedial action is taken.

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