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ACID RAIN - A CHALLENGE FOR EUROPE

Introduction

The Commission of the European Communities, together with the "Kernforschungszentrum Karlsruhe" (KFK), is organizing a Symposium to review both present knowledge and further research requirements on a broad front. The Symposium on "Acid Rain - A Challenge for Europe" is to be held in Karlsruhe from 19 to 21 September 1983.

Behind it lies the experience that reality can come to resemble fiction and gloomy presentiments can turn into harsh reality. This applies above all things to man's spoliation of nature - as is clear from the example of acid rain. Precipitation carrying a whole range of atmospheric pollutants is insidiously ravaging our planet. Although the origin and effects of this phenomenon of the post-industrial age are still uncertain, one thing is definite: acid rain - particularly in Canada and Scandinavia - has done incalculable harm to lakes and rivers - destroying many forms of life from fish down to microscopic plants. It is also suspected that it removes nutrients from poor soils on which forests grow.

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Damage due to attack by acid rain to structures and water supply systems is costing millions of units of accounts every year. And a general health hazard arises from contamination of drinking water - for which acid rain is partly responsible. All these harmful consequences for man and his environment are graphically expressed in the description of acid rain as "insidious malaria of the biosphere". The acid rain problem is becoming more obvious every day. This prompts a number of questions for policy-makers and scientists alike: What are the causes and how does the chain of causation work? How urgent is the problem? Finally, what is to be done? The scientists have not yet answered these questions in full. Despite considerable progress with research in recent years gaps still remain in the scientific understanding of acid rain.

Acid rain is no respecter of frontiers and its differing effects in practically all Member States are a challenge to the European Community. Our scientific understanding of the problem must be improved if effective rules to protect the environment are to be formulated. The purpose of the planned Symposium is to provide that better understanding. The main aims are to collate the known facts and to identify and delineate the gaps in our knowledge. This makes the Symposium, in one sense, a "conference of conferences".

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The dark origins of a silent scourge

How acid rain forms in the atmosphere is still in many ways a puzzle to many scientists. Natural phenomena such as volcanic eruptions, forest fires and the breakdown of organic substances by bacteria can produce the acid compounds of sulphur and nitrogen which cause acid rain to form. In that case, however, the process is cyclical, unlike the continuous accumulation resulting from acid rain. To many experts, therefore, the sources of pollution are seen to be thermal power stations, district heating, motor vehicles, industry (foundries and smelters in particular) and households and small consumers emitting sulphur dioxide (SO_2)

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and oxides of nitrogen (NO_x) into the atmosphere. The scale of pollution from these sources varies between countries. In the Federal Republic of Germany (FRG) 56% of SO_2 pollution is attributed to thermal power stations, 28% to industry, 13% to small consumers and 3% to motor traffic. Still in the FRG, 45% of NO_x pollution is put down to motor vehicles, 31% to power stations, 19% to industry and 5% to small consumers. In the Netherlands, for example, traffic gets the blame for 5% of SO_2 pollution and 55% of emissions of oxides of nitrogen, while 75% of SO_2 pollution and 25% of NO_x pollution are put down to power stations and industry combined. It follows that in the FRG and the Netherlands power stations and motor vehicles are the chief sources of SO_2 and NO_x pollution respectively. But "acid rain" is a catch-all term for a number of pollutants resulting from combustion processes. In addition to sulphur dioxide and oxides of nitrogen, acid rain contains heavy metals such as mercury and cadmium, and carbon monoxide and photochemical oxidants. Interactions among this variety of substances seem to intensify their harmful effects considerably.

When discharged into the atmosphere, sulphur dioxide and oxides of nitrogen are carried by prevailing winds and react with water (in the form of vapour, rain and fog) to produce acid derivatives. Sulphur dioxide and water, for example, form sulphuric acid (H_2SO_4); nitrogen dioxide and water, for example, form nitric acid (HNO_3). Together with hydrochloric acid (HCL) which results chiefly from the burning of plastics, sulphuric acid and nitric acid are considered responsible for the production of acid rain. Conventional combustion technology, however, also releases considerable quantities of products of incomplete combustion, e.g. carbon monoxide (CO), aldehydes, hydrocarbons and soot. Particles may be emitted in the form of "fly-ash" measuring a few tenths of a millimetre and consisting chiefly of iron, silicon, aluminium, magnesium, trace elements and carbon. The amount of fly-ash released depends on the combustion temperature and the ash content of the fuel. Fluorides and selenium, for example, may also be released in gaseous or vapour form. The burning of fossil fuels may also cause major emissions of highly toxic heavy metals such as lead, cadmium, and mercury which are often adsorbed on fly- ash. In the FRG combustion systems cause 39% of all cadmium emissions.

Under certain climatic conditions photochemical oxidants (e.g. ozone) may arise from air pollution as a result of conversion processes. The longer pollutants stay in the atmosphere, the more photochemical oxidants are produced. Accelerated dying-off of forests in Bavaria in 1976 - a dry, sunny year - was partly attributed to the effect of photochemical oxidants, ozone in particular.

Death of lakes and forests

Acid rain, carried by prevailing winds, very often falls hundreds of kilometres from where the pollutants originated. No way has yet been found of precisely determining the source of acid rain, although experiments have been carried out to track it through the atmosphere. At all events, about 50% of pollution returns to the surface dissolved in rain (wet deposition), the remaining 50% deposits directly out of dry air on strutures and crops (dry deposition). Where dry deposited material is dissolved - in dew for example - highly acid solutions may be produced. The effects of acid precipitation are still not satisfactorily understood; but its origins are even less clear. Acid rain, having a pH below 5.6, alters the pH of lakes and rivers when it falls directly into them, causing their biological death. When absorbed by soils it leaches out the natural base minerals such as potassium, calcium and magnesium, and entrains them into the subsoil, so removing a major source of mineral nutrients for plants and trees. The damage continues when the rainwater reaches the water table, for it often carries a load of dissolved toxic metals, such as aluminium, which may arrest the growth of aquatic organisms or kill them outright. With repeated falls of acid precipitation, lakes and rivers become strangely clear and take on a bluish tinge. Any surviving microorganisms are then trapped at the bottom under a layer of sphagnum moss, so that the water can no longer sustain any but the most primitive forms of life. In soil the taking of toxic metals into solution generally causes the roots of trees to rot away. For a while it was believed that liming would be enough to restore soils to health.

Social and economic disaster for the forest-products industry

In the Federal Republic of Germany, the worst affected EEC country, 560 000 hectares of forest are classed as "completely devastated areas". All Länder are affected, the worst hit being Bava ria (160 000 ha), Baden-Württemberg (130 000 ha) and North Rhine-Westphalia (over 70 000 ha). It is believed that two million hectares of coniferous forest show signs of acidification - over half of the coniferous forest in Germany. On some estimates the resulting loss of production will wipe out 47 000 jobs in the German forestry and wood-processing industry (out of a total of 800 000). According to the experts, the estimated damage to forests throughout the European Community costs 100 million ECU a year and is definitely on a rising trend. Since one-third of the EEC's agricultural land, amounting to some 35 million hectares, is under forest, the problem caused by acid rain is of prime importance not only for environmental protection but for the economy as a whole. The forest products sector employs 1.4 million workers in the Community, which puts it in the same league as the motor, chemicals and textiles industries. Large forest areas have also been affected in the Netherlands, German Democratic Republic, Czechoslovakia, Poland and Yugoslavia.

Unlike its forests and soil, the Community's aquatic environment seems to have been relatively spared by acid rain. On the other hand, acid rain has killed off all forms of flora and fauna in most Norwegian lakes, which are now regarded as "biologically dead". In Sweden about 20% of 100 000 lakes seem to have been harmed by excess acidity. Fish have died out in 2 000 to 4 000 lakes in the Province of Ontaria, Canada, in 1 800 lakes in the Province of Quebec and in over 10% of the large fresh-water lakes in New England and the Oldivouslacks and Adirondacks Mountains, USA.

Rotting stonework

It is also apparent, however, that sulphur dioxide and oxides of nitrogen attack a very wide range of materials - generally hard-to-replace constituents of the chief products of the industrial society in which we live. Through processes which are not yet fully understood, acid rain is believed to reduce the life of metals, limestone, concrete, cement, paints and varnishes, and paper and textile fibres.

In the Netherlands the figurative and decorative stonework on the outside of Sint-Jans-Kathedrale, 's Hertogenbosch, which is 458 years old, is said to be melting like toffee. The museum of mining in Bochum loses 4% by weight of its structure each year. The Parthenon in Athens, the Colosseum in Rome and most of London's historical monuments have already been seriously damaged by acid rain. In England studies have shown that the rate of corrosion of nickel is 6 micromillimeters a year in the severely polluted atmosphere of Birmingham, against an average of o.25 micromillimetres a year in rural areas. Acid rain also seems to harm human health both through the inhalation of the pollutants and the uptake of heavy metals in food and drinking water.
According to the Organization for Economic Cooperation and Development (OECD) the estimated cost to EEC member countries of the damage now caused by acid rain to materials, crops and public health is 3 to 5% of GNP.

Heavy metals and acid rain

Heavy metals as a factor in air pollution in their own right have so far attracted little research effort. As elements they are not degradable. A study carried out at the University of Göttingen has shown that these toxic metals accumulate in the topsoil, so threatening crops. This is amplified by the effect of acids, since these heavy metals, and those naturally present in the soil in the form of non-toxic compounds, are highly penetrating. The needles, leaves and rootlets of affected forest trees show high concentrations of heavy metals. These generally accumulate in food chains, making fauna, fish and mushrooms unfit for consumption in some areas, because the uptake of heavy metals causes diseases of the central nervous system. When fixed to dust or suspended particulates, heavy metals can also penetrate deep into the lung tissues.

Pollution control: a cost-effective investment

An information note published as a working basis for the public hearings on acid rain held by the European Parliament's Committee on the Environment in Brussels on 19 and 20 April 1983 pointed out that with present technology more than 95% of these pollutant emissions could be prevented. Any problems, therefore, are to be found at the political decision-making level or in the field of legal and administrative powers. The note also emphasized the point that on financial grounds fuel desulphurization, the use of clean combustion technologies and flue-gas scrubbing seem to be the most appropriate remedies. According to the OECD, damage caused by acid rain to forests and the land in the Federal Republic of Germany is believed to amount to some 10 000 million marks and SO_2 emissions could be reduced by half by investing the same sum of money. In view of the many consequences of environmental pollution due to acid rain (for buildings, metals, water, etc.) such an investment would clearly be profitable. The social benefit of pollution-control measures would substantially outweigh their social cost.

Why should the European Community act?

Since it is now an established fact that acid-rain pollution is a transfrontier phenomenon, it was logical for it to be one of the concerns of the Community authorities. At the prompting of the Federal Republic of Germany - the only Member State planning measures in the short term for a substantial reduction in the emissions assumed to cause acid fallout - the European Council (Heads of State and Government of the Ten) has dealt with this issue at its last two meetings. At Stuttgart in June 1983 the Ten decided that irreversible destruction of forests by acid rain could only be avoided if effective and coordinated steps were taken urgently both at Community and international levels. Mr Gaston Thorn, President of the European Commission, went to the Black Forest last March to establish at first hand the extent of the environmental degradation due to acid rain. But the European Community had already taken a number of measures in recent years to limit air pollution.

Notable among these measures was the introduction in 1975 of a common procedure for the exchange of information between the surveillance and monitoring networks on sulphur compounds and suspended particulates. This was renewed in 1982 and extended to further pollutants - ozone and oxides of nitrogen in particular. Regarding the setting of air-quality standards, the EEC Council of Ministers adopted a directive in 1980 laying down limit values and guide values for sulphur dioxide and suspended particulates; in 1982 it adopted a further directive laying down a limit value for airborne lead.

Products have not been neglected: a directive adopted in 1975 lays down the maximum sulphur content of certain liquid fuels of the gas oil and diesel types; another, in force since 1978, sets an upper limit for the lead content of petrol. A directive on exhaust gas emissions from motor vehicles has also been in force since 1970. It lays down compulsory maximum emission standards for carbon monoxide and unburnt hydrocarbons. These standards were tightened in 1974, 1977, 1978 and 1983 and have been extended to oxides of nitrogen. Since an assessment of the hazards to human health and the environment due to various pollutants is necessary, the Community has since 1973 undertaken a number of research projects, e.g: on the remote sensing of air pollution; the physico-chemical behaviour of atmospheric pollutants, including oxides of sulphur and oxides of nitrogen (COST Project 61a bis); and an Environmental Protection and Climatology Programme. At international level, the EEC ratified the Geneva Convention on long-range transboundary air pollution in July 1982.

Filling gaps in Community law

In addition to those measures implementing Community directives, the Member States have taken a variety of others to limit air pollution. Prominent among them are licensing or reporting schemes for particular categories of industrial plants. In a communication to the European Council of Heads of State and Government, Stuttgart, June 1983, the Commission nevertheless expressed the opinion that the various schemes in question have to be supplemented where Community directives imposing standards have not all been implemented to the same extent by the Member States.

The reason is that some of the directives in question leave a great measure of flexibility in implementation as regards emission limits. Apart from the fact that Community standards cover only some of the pollutants which go to form acid rain, the Commission also acknowledges that the levels at which these standards were set were chiefly dictated by considerations of public health and that environmental considerations, which sometimes require more strongly binding measures, were not always fully taken into account. These factors combine to produce marked disparity in national measures which affect production costs differently in the various Member States and may in some cases lead to distortions of competition.

On all these grounds - not forgetting the increasing severity of observed acid fallout - the Commission decided, starting in 1983, to enact more Community law on air pollution. Early this year it put to the Council of Ministers a proposal for a framework directive on the control of air pollution from industrial plants. This proposal for a directive, the first with a general scope in the air pollution field, essentially requires Member States to take the necessary steps to introduce prior authorization for the construction of industrial plants liable to cause air pollution. It was given a first reading by the EEC Environment Ministers in Luxembourg on 16 June and seems to have been given a favourable reception by the Member States' representatives. The European Commission is now drafting the first proposal for a directive implementing the framework directive in order to limit emissions from large combustion plants, which are generally regarded as being chiefly responsible for acid rain. The Commission also plans to put up shortly a proposal for a directive laying down air quality standards for nitrogen dioxide. Concurrently it is also engaged in a technical and economic study of all pollution problems due to motor vehicle emissions and will in the very near future put to the Ten proposals based on the outcome of its research and aimed at improving the relevant Community law.

A specific proposal for protecting forests

Under the common agricultural policy (CAP) the Commission sent to the Council in July 1983 a proposal for a regulation designed to protect forests against fires and acid rain. In the acid rain section of the proposal the Commission's aim is to institute a specific scheme of action on acid fallout affecting forest ecosystems. The proposal, then, is for 5 million ECU to be laid out annually for a five-year period on:

- Setting up a network of stations for the surveillance (observation and measurement) of acid precipitation affecting vegetation and soil in the Community's chief forest areas.
- Establishing interdisciplinary scientific teams with the chief task of developing appropriate preventive and remedial procedures based on the data gathered by the surveillance network.
- The coordination of interdisciplinary scientific research by the Commission - chiefly centrally collating the information and utilizing the results with the assistance of research institutes and a scientific committee.
- Running pilot projects in forest areas which are seriously affected to varying extents in order to provide demonstration sites for the dissemination of preventive and remedial procedures in readily understandable form.

The Commission's aim in this is to acquire the means of making a thorough study of the under-explored problem of acidification and its impact on fauna, flora and the fertility of soil and water. This proposal therefore partakes of the same broad purpose as the Karlsruhe Symposium, the aim of which is to review present knowledge and intensify Community research on the effect of acid rain on the environment.

Filling the gaps in scientific knowledge in order to legislate

Not only industry - some of whose spokesmen fear that measures to limit its emissions may bring a considerable increase in their production costs - is divided on the acid rain issues: so are the scientists.

Although sudies in both North America and Europe have established that emissions of sulphur dioxide and oxides of nitrogen are the cause, some research workers maintain that the acidity of rain is not increasing; they argue, for example, that changes in the biology of lakes are due to natural (geological or biological) factors. They also generally cast doubt on the claim that a 50% reduction in SO_2 emissions would stem the catastrophe; they make the point that this figure has no firm scientific basis. Although these arguments are disputed by the majority of scientists engaged in research on acid rain, there are few research workers who deny that there are still major gaps in our understanding of the phenomenon. And so far it has indeed not been possible to pinpoint the source of acid rain. Likewise, the chemical reactions through which SO_2 and NO_x are converted into compounds of sulphur and nitrogen in acid rain have not been fully elucidated; likewise with their interactions with heavy metals, carbon monoxide and photochemical oxidants. The origin of acid rain may still be somewhat unclear; its effects are less so. And, though some unknown factors may remain, the chief question at this level is how much of this pollution can ecosystems take without risk of degradation. The answer will determine the ability of governments to fix permitted pollutant emission levels.

To formulate effective legislation for dealing with acid-rain pollution requires a comprehensive understanding of the phenomenon. Since a number of unknown factors remain, the Commission has taken the view that a symposium to review the present state of knowledge and put Community research on acidification of the environment on a broader basis could be the first step towards that goal. To be more precise, three objectives will be pursued in Karlsruhe between 19 and 21 September, namely:

- To seek a consensus on the origins, effects and socio-economic consequences of acid fallout both now and in the immediate future.

- To review the technologies available for reducing and eliminating SO_2 and NO_x emissions and possible ways of improving them.

- To identify research, development and demonstration requirements in this field.

Papers on the following themes will be presented by scientists of international standing:

- The origin, conversion, transport and deposition of atmospheric pollutants.

- The effects of atmospheric pollutants and acid fallout.

- Emission-abatement technologies.