A PRESENTATION OF THE NORWEGIAN PROJECT "ACID PRECIPITATION - EFFECTS ON FOREST AND FISH"

LARS N. OVERREIN, Ph.D., Director, The SNSF - Project,
1432 AAS - NLH, Norway.

INTRODUCTION

Air pollution is an international problem of the greatest dimensions. The continuous expansion of production and consumption in modern society is accompanied by the steadily increasing emission of air pollutants of different types. It is generally recognized that air pollutants can be transported in substantial amounts over distances of 1000 - 2000 km. This phenomenon has been studied with special attention being focused on acid sulphur compounds, which are the main cause of acid precipitation.

The Norwegian research program entitled "Acid Precipitation -- Effects on Forest and Fish" (or the SNSF - Project) was undertaken to study such problems. The present paper discusses the evolution of that project and some of the research areas in which it is now involved.

THE SNSF - PROJECT

The long range transport of air pollution in Europe has caused many problems. Through the Organization for Economic Cooperation and Development (OECD)-Project, "Long Range Transport of Air Pollutants," considerable progress has been made in establishing the connection between emissions of air pollutants, weather conditions and concentrations in precipitation areas in Europe. Southern Norway is especially exposed to increased precipitation from winds between the southeast and southwest. These air streams almost inevitably have passed over important emission regions within the industrialized belt across Europe. The precipitation that is caused by the mountain ranges in southern Norway will, therefore, often contain high concentrations of pollutants from remote sources. The severity of the air pollution problem, particularly acid precipitation, becomes obvious when we recognize that 80% of the productive forest land in Norway is dominated by acid podzolic soil, and that thousands of lakes are located on acid granite bedrock.

Long range transported air pollutants are recognized as the most acute environmental problem in Norway today; the problem is of sufficient importance to justify extensive studies. Therefore, in 1972 the nationwide joint research project, "Acid Precipitation - Effects on Forest and Fish" was initiated as a result of action taken by the Government and two Norwegian Research Councils. This modern research effort is organized strictly as a project-oriented, cross-institutional, self-governing entity. More than ten Norwegian research institutes participate in this project, involving nearly 50 scientists and a large supporting technical staff. The Norwegian government has recently increased its budget allocation for this project by a significant amount, thereby indicating the importance and reality of the acid precipitation problem to Norway. The government has clearly shown its intention and willingness to do something about the problem.

The main objective of the SNSF - Project is two-pronged:

1) To establish as precisely as possible the effects of acid precipitation on forest and fresh water fish, and

2) To investigate the effects of air pollutants on soil, vegetation and water, (to the extent required for paragraph 1).

The data from this research project will be used as a scientific contribution to the forthcoming international negotiations aiming at control of the overall emission of air pollutants.

SNSF RESEARCH PROGRAMS

AIR POLLUTION DEPOSITION

Air pollution occurs primarily in the central mountain region of southern Norway. Close cooperation with the OECD - Project, in which the Norwegian Institute of Air Research acts as the Central Coordinating Unit, gives the SNSF - Project the possibility to utilize forecasts of polluted air streams, their origin and time of arrival. This allows our research teams the time necessary to reach various field stations prior to the arrival of the precipitation that carries air pollutants. All of Norway is used as our field of operation.

Two examples of such pollution are: 1) During the period 5-13 January 1974, the southernmost part of Norway received precipitation as snow containing 850 kg sulphate per km^2 , of which approximately 90% was sulphuric acid. The precipitation arrived on southeasterly winds with contributions both from eastern and western Europe, 2) During an 8-day period in January 1974, the southwestern parts of the country received over 20,000 km^2 precipitation from Great Britain amounting to 4,000 tons

of sulphate corresponding to 100% sulphuric acid.

In addition to the deposition by precipitation, air pollutants may also be absorbed and adsorbed by vegetation and by the ground. This dry deposition accounts for the removal of a substantial amount of pollutants from the air. In some cases the concentrations of various pollutants in precipitation under exposed trees have been found to be 2-3 times higher than in open terrain. The degree of dry deposition is closely associated with the total active surface exposed to the polluted airstream. Figure 1 shows the tip of a single spruce needle as seen by

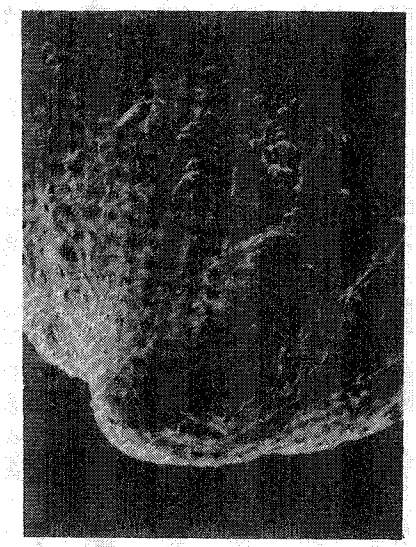

Figure 1. Tip of a single spruce needle photographed by an electron microscope.

an electron microscope and demonstrates the scale on which this deposition phenomenon occurs.

In addition to the acid forming compounds, polluted air and precipitation also contain heavy metals, soots and tar products from combustion processes. The presence of organic micro-pollutants has also been demonstrated both in precipitation and as dry deposition. Great efforts will be made to quantify the total deposition of the various air pollutants, particularly within the most heavily exposed areas of Norway, especially southern Norway.

EFFECTS ON THE FOREST ENVIRONMENT

The effect of pollutants on the forest environment is one of the

most important questions within the SNSF - Project. The growth response is a result of interacting physico-chemical and biochemical processes. Intensive studies are being carried out to quantify the damage caused by the long-range transported air pollutants with regard to forest growth. However, at present, it is not possible to draw any definite conclusions.

Extensive experiments with spruce, pine and birch are also underway in phytotrons, nurseries and under field conditions where air pollutants at various concentrations and compositions are added. On the basis of existing knowledge, it is possible to assume that the total production potential will be reduced and that some plant communities will disappear almost completely as a result of gradual acidification of the soil in the more susceptible regions of the country.

EFFECTS ON AQUATIC ECOSYSTEMS

An increasing acidification of the water in watercourses in southern Norway has been observed in recent years. There are many examples which indicate that streams, rivers and lakes can be exposed to heavily polluted loads of acidifying components and other air pollutants, particularly in connection with episodes of strongly polluted precipitation. The topography and the geological conditions are of great significance in this connection. There are clear indications that the chemical composition of water within a precipitation area is altered as a result of the pollutants which are added through precipitation and possibly through dry deposition.

When precipitation falls in the form of snow in the winter, pollutants are accumulated over a long period of time in mountainous snowfields and then transmitted to watercourses when the snow melts. During the winter a vertical transport of pollution occurs. A resultant accumulation of pollutants in snow has been demonstrated, which means that the pollutants collect in the lower layers and are then released in more concentrated form at an early stage in the melting process, at a time when the water level in watercourses is still low. This can lead to sudden and acute increases in water pollution levels. Measurements taken during the spring thawings of 1974 and 1975 have shown pH levels in the vicinity of 3.0 in run-off water from snowfields. In addition, substantial amounts of heavy metals and also organic micropollutants have been found in the run-off water. These problems are undergoing intensive study through the SNSF - Project.

INLAND FISHING

Inland fishing in southern Norway has suffered severe setbacks in recent years, caused mainly by acidification of the water. The majority of these waters are extremely poor in organisms and have completely lost

their fish populations. This is the present state of affairs in thousands of localities, particularly in the southern part of the country. Intensive studies are being undertaken to gain more scientific knowledge about the effect of air pollutants on fish and important fish food organisms.

As an illustration, when fish, collected from the field, are immediately exposed to water from some of the highland rivers during the spring snow melting, they most likely die after a few hours. In studies of this type, great attention is paid to the physiological effects of pollutants. In modern mobile field laboratories, details about blood chemistry, ionic exchange mechanisms, respiration and neuromuscular response are studied.

Field experiments on spawning and hatching have also revealed a dramatic effect of high acidity. Oligotrophication, a self-accelerating process, is apparently underway in many of our lakes and rivers. Acid precipitation affects the aquatic ecosystem in such a manner that it becomes controlled primarily by physiochemical factors rather than by biological mechanisms.

Where does this end? We may be approaching "the silent spring" which may be an appropriate term to refer to the outlook for many lakes and rivers in Scandinavia as the linking of these effects along trajectories from major emission sources in Europe becomes more and more apparent.

SUMMARY

The severe and continuing depletion of fish stocks in Norwegian lakes and rivers provides ample justification for our grave concern over this problem. Even more so, the project is seriously concerned with the long-term impact on the environmental systems of the forest and mountain regions.

On the international scale, total emissions in the years to come are expected to increase. For this reason, Norwegian governmental officials have asked me to express their appreciation to the United States of America for initiating this conference hosted by this great State of Ohio. The Chairman, on behalf of the Technical Program Committee, has expressed hope for effective communications among concerned scientists. In the very same spirit, I have been personally asked by the Norwegian Ministry of Environment to announce plans for an international conference on the effects of acid precipitation to be held in Norway in June of 1976. This conference is expected to cover topics related to effects of acid precipitation on soils, vegetation, water, materials, and human health.

Such conferences as the First International Symposium on Acid Precipitation and the Forest Ecosystem and the one planned for 1976 convey the magnitude and complexity of the air pollution problem, which in turn reveals the need for better scientific understanding. In trying to protect the environment today, we shall take into account the great responsibility that each of us shares with respect to the generations to come.