

GENERAL SURVEY OF EFFECTS

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One of the characteristics of mankind is summarized by the word "Culture". It implies our way of life, our social structure, our history, the way we live and feed ourselves and our concepts of the future. It concerns the relation we have with each other and with the world around us.

History, religion, esthetics, ethics and many related concepts are commonly used words although their interpretation has often varied depending upon the period and the type of culture we live in.

It is comparatively new that the word environment has become a household word. Our attitude toward our environment is now an explicit part of our culture and is an issue in our daily life and work. Environment is becoming an ever growing concern all over the world. The problems have mainly originated in the technologically advanced countries, but are now a concern right into the most remote regions of the earth, even as far as the polar areas both in the north and the south.

Environment has long been an object of study in biology and it is gratifying for the biologists that much of the work that has been done, has now acquired a much wider significance. The investigation of the relations between organisms and the physical, chemical and biological structure in which they function, which since a hundred years is called ecology, is now a wide spread occupation. Not only biologists, but also many others begin to realise the importance of this discipline for the future of mankind.

It is much less spectacular than astronomy with its breathtaking view of the universe, or than molecular biology with its astounding insight into the working of living organisms. It does not require expensive or complicated instrumentation. The results are obtained mostly by many years of painstaking and often unobtrusive work, which does not impress the layman. But the results are of the utmost importance for deciding how we are going to shape our future.

One of the characteristics of ecology is that it requires a multidisciplinary approach and that only a wide knowledge of the implications of data from other disciplines makes advances possible. The complexity of the subject also makes the formulation of the problems more difficult than in monodisciplinary re-

search.

The 20-odd papers which have been presented at this conference show this aspect clearly. They have been prepared by scientists from widely different fields, they approach the problem in different ways and quite often explicitly draw attention to the necessity of integrated studies.

In the context of our cultural heritage it is perhaps the most astounding fact that we have let the pollution of the atmosphere continue to such an extent that our proudly conserved monuments are falling to pieces all over the world. The papers which explicitly are concerned with this item show that we now know how serious is the damage to our buildings and to our archives, what the causes are and that we must stop it. The decision to do so now is ours.

All this damage is due to a different aspect of our cultural achievements, which is the satisfaction of our urgent wish to increase our personal comfort: heating when it is cold, coolness when it is warm, light when it is dark, transport when we need it or just think it is fun to travel around, and all the instrumentation and gadgets which make up such an essential part of our daily life. We take these all for granted and we do not realise how their production and use require energy, and that energy production is the main source for the air pollution.

We are so eager to maintain and increase the quality of our living conditions here and now, that we are not willing, or perhaps I should say not capable of realising the fact that we are achieving results that are splendid in the short term view but will be catastrophic in the long run. Mankind, for long ages, has been living from day to day trying to stay alive and keep their families alive in a very hostile environment. Even today for millions the future does not go much farther than the effort for the next meal. This has structured our way of thinking so strongly that it takes more than one or two generations to learn that we must look much farther ahead. It is necessary to know what will be the consequences in the future of the things we are doing today.

This is a problem where our sociologists and psychologists should be urged to make further studies, in the hope that understanding why we behave as we do, will give us indications how to alter our way of living.

We have seen how bad the situation is with our cultural environment. Let us now look at our natural environment.

It is clear that the two main topics for Northern-America and Europe are the lakes and the forests. We know, of course, that the problem is much wider than these two keywords suggest.

The acidification of oligotrophic lakes and streams stems mainly from sulphur dioxide-emissions from burning fossil fuels. Of course doubts have been expressed whether this really was the cause. The main alternative suggested has been that too long continued cultivation or changes in the use of certain soils, has been the main cause for acidification of natural waters. It is now clear that this is not the case. Sufficient evidence is available to show the direct relation between sulphur dioxide-emissions and acidification of waterbodies.

Although it was not mentioned during this conference I draw your attention to one particular item in the process of resolving this question.

Hydrobiologists have since long established that the composition of the microflora of lakes depends upon the amounts of nutrients present and the acidity of the water. In particular the Diatoms show this relation quite clearly in their species composition. These unicellular plants have skeletons of silicium-oxyde. When they die their skeletons sink to the bottom and remain there intact for a very long time. By studying bottomsamples the sequence of Diatom populations can be traced over very long periods. In this way it has been established that acidification does not correlate with changes in agricultural practice but with the increase of fossil fuel burning.

From a science policy point of view this is more significant than just this study itself implies. Such studies can only be made by specialists in Diatoms. This silent group of taxonomic biologists has been working, hardly noticed by the community and certainly not respected as important people. Now their accumulated knowledge has made it possible to demonstrate an important fact. It is an unexpected application of what for a long time had been considered a purely scientific interest.

And then again just identifying Diatoms is not enough. These studies must be combined with those of specialists who may have been working on pollen, or cli-

mate, or the history of agriculture, or on radiocarbon dating. Only interdisciplinary exchange of knowledge can deepen our insight in what is going on around us.

Once having established that SO_2 is such an important factor, the question arises: where does it come from. The transboundary transport of air-pollutants has been established as a fact and the quantitative data are becoming more and more precise.

This is a problem for the policy-makers. We know that certain things are happening, but we do not yet know how to cope with the situation. The Minister in his opening speech for this conference drew attention to this point. The data are there with sufficient accuracy to be a basis for a political solution.

This conference has as an overall title "Acidification" and we use the word easily although not always accurately. This should not obscure the fact that our problem is not just the acidity alone, but that it is a very complicated question with a great many different aspects. Apart from the direct relation between water and air, also, the soil is an important subject for our considerations. And soil is an extremely complicated system with physical, chemical and biological components and all their pluriform interrelations.

Soils develop from weathering rocks and the rock thus is of prime importance for the soil which it generates. The reaction of the soil to acidification depends to a large extent upon the composition of the underlying rock.

In the Scandinavian countries the recently developed post-glacial soils and waters are much more sensitive to acidification than many of the Central-European soils, which are derived from more basic rocks. As you have heard, in the northern part of Europe it is the waters that suffer most. In the more central part it will be the soils which first show the negative effects of acid deposition. Parallel situation will no doubt be found in North-America. Obviously the attempts at the restoration of the damage will have to be different in the different areas.

There is a time lag in all these processes. Not only does it take time for the damage to manifest itself clearly, we now also know that even if we reduce

the amount of acid products which are emitted into the atmosphere, it will not have a direct effect on the water and even later on the soil. Because of just this time lag it becomes the more urgent to act as soon as is possible.

Percolating water gets into aquifers and other underground water bodies and thus into drinking water. Through this route human health is directly threatened. Both in soils, including under-water soils, and in piping systems, metals dissolve due to the acidity of the water. Particularly aluminium and copper are the ones most dangerously involved. It means that the toxicity of water can increase up to a dangerous level. It is the direct cause of fish mortality and a potential, if not actual, danger for the health of other organisms including man.

As regards forests it is much more difficult to give a detailed picture of our knowledge. While on the one hand it is agreed that something unique and spectacular is taking place in large areas of the northern temperate zone, there is some difference of opinion as to the interpretation of the phenomenon. According to some we should be more aware of the fact that there is a continuous process of decrease and increase in the state of health of forests, a pendulum of quality which underlies the observed facts of the present years.

As data from research, however, accumulate it becomes more and more clear that, though this may well be a legitimate point of view, we must accept that now something out of the normal is taking place. There is now general agreement that air pollution is the main cause of the large scale die-back of the forests.

But there are still quite a number of important questions to be answered. The relative significance of factors involved is not assessed in the same way by different experts.

We would like to get answers to our questions quickly and accurately. Unhappily that can not always be achieved. There are too many elements involved; different species of trees and other plants, different soils and water regimes, climatic conditions and atmospheric processes make an analysis no easy matter and require time. All the same the papers already provide us with a wealth of information presented during this conference, to which I have been continuously referring and will continue to do so.

Quite clearly there are periods of good growth and periods of stagnant growth and higher mortality in forests due to the very intricate system of external and internal reactions in all the separate organisms involved.

The word stress has been introduced in the presentations and it is a useful concept. It denotes the fact that we find similar phenomena in trees and in stands which cannot always be directly assigned to specific causes. Drought, high water table, insects, fungus and bacterial diseases, gradual changes in the soil condition and climatic variations all have their influence on trees and they exert their influence simultaneously. At the same time these different factors are interrelated in a way which we do not yet completely understand. To analyse them, experiments have to be performed. Only a good scientist can interpret these results for the benefit of extrapolation to general conclusions. To get results which have wide application we need very extensive experiments with a great variation in factors as regards soil, climatic factors and species of plants.

The variation of resistance to negative effects has been discussed. Although selection of resistant varieties is an effort we should not neglect, it does not seem to be a way that will solve all our problems in good time.

Much of the information presented here during these days shows the complexity. We can study the composition and influence of the surrounding air in which open-top chambers now play an important role. Combinations of sulphur-oxidants like ozone, can be introduced in the experiments, which, however, will take many years to complete.

In a number of countries, including the USA, USSR and BRD, ozone has been shown to be a major factor. Sulphur-dioxide alone does not give the damage we observe in the field unless we use very high concentrations. But together with nitrogen-oxides and hydrocarbons it does. The complexity of the structure and function of plants makes it necessary to perform long term experiments, under carefully controlled conditions. Only in this way can we unravel the physiological processes. It is necessary to study the microscopic structures in which these processes take place also. The structural changes that can be observed give us a better possibility to explain what is happening in the plants.

Further there are the soil and its changing conditions, that have strong interconnections with the physiology of the plants. You must allow me here again

to draw attention to the fact that only decades of fundamental research have given us the concepts, knowledge and tools to approach the problem of forest die-back in an adequate way.

The soil is as yet poorly understood. We need to know more about the influence of acidification on the organisms in the soil and their functioning. Our lack of knowledge is a great drawback, as these biotic elements are so very important in soil processes, including the production of mineral nutrients for the plants. We need a great wealth of data to give a more precise explanation of what we observe, and to be able to foresee what will be the effect of our attempts to improve the situation. In particular the mycorrhiza, so important for many tree species, may suffer considerably from changes in acidity and changes in the functions of the soil under influence of pollutants.

In some of the papers attention has been drawn to the problem of how to measure items in the biotic and abiotic components of our ecosystems. We need standard techniques where possible, we need methods applicable under very diverse circumstances, we particularly need techniques to help unravel complex problems.

We have been told quite clearly in the last few years that the dry deposition is as important a factor as the wet deposition. We now know also that dry deposition may dissolve in dew and thus create high concentrations of toxic components on the leaves and in the run-off along the trunk of the tree. Thus considerable amounts of these substances are directly transported to the soil.

Consideration has been given to the relation between natural and man-made acidification. Although natural acidification occurs widely, the rates are slow as compared with what man-made acidification is doing now. The natural process cannot be used as an excuse not to do anything about our pollution.

Sumarizing it is obvious that air pollution is responsible for such a major part of the damage to the forests that further pollution should be stopped and that it must stop soon. As one speaker put it: "We should not continue to experiment with nature".

In recent times we have learned to use mathematical models to help solve problems and help find practical solutions, particularly with a view of future de-

velopments. That is to say some of us have learned to work with them, and others, though not capable of building them or handling them, have learned to appreciate their very great value. Particularly in environmental problems modelling has helped a great deal to clear our minds. In the search for ways to resolve differences in futurological considerations they are an important tool. Attention has been given to its role in our present concern and the conclusions are important. They show us what will happen if we do not use the knowledge we have available, and how that knowledge, if properly handled, will tell us what to do. Here again we are quite unavoidably confronted with the fact that postponing action for the sake of short term gains will lead us to a situation with serious and often irreparable long term losses.

This brings us to the economic aspect of our problem. Several calculations have been presented. They are estimates and do not claim precision. The figures are already considerable and the trend in the estimates is certainly an increasing one. This should be energetically pursued because we need more values expressed in money, because money is a word that may convince those who have not yet appreciated the damage which is being done.

We know now that damage to modern buildings and metal constructions can be reduced with great costs by protecting covers, but this does not help us much in solving the whole of the problem, the dangers for water, soils, plants and human welfare. It does help us to realize how extensive the overall damage is.

The cost of the distribution of lime where it has been applied in agriculture, forests and in lakes in certain parts of Scandinavia and elsewhere, already shows the amounts we have to spend to correct a fraction of the damage which has been inflicted. The damage to agriculture is already estimated by some researchers to be about 10% and in a number of cases up to 40%, of the possible production, truly a terrifying figure. Long term studies will have to give us more precise data. But economic considerations make it quite obvious that any sensible approach will have to be international so as to get maximum value for the national effort.

One of the aims of this conference is to bring together research-scientists and policy-makers, with the common concern of what to do about the pollution of our environment.

A problem that then presents itself is how to translate the results of research into data that policy-makers can use in their work.

One part is the question how to use the so-called fundamental research. This essential part of what many of us are trying to achieve is often considered just the hobby of some unrealistic scientist of the old school. It is strange that this opinion still goes round, because sufficient evidence has been presented to show that technical improvements in our way of life are based upon applied science, which cannot expand without fundamental knowledge of physics, chemistry and biology. The observation that social sciences cannot always help to answer questions, to some extent might be due to the fact that they have not had time to develop their basic system of thinking. Natural sciences, as we now understand that concept, are some three centuries old, social sciences, however, only about three quarters of a century.

Restriction of fundamental scientific research is a policy which still persists in a number of countries and will, within a decade, reduce the productivity of applied science and technology. Those who come after us will not be grateful for such a policy.

I would like to draw your attention to one specific point. It is the fundamental difference in ways of thinking between the scientist who produces the results and the policy-maker, who has to work with the results of scientific research.

For science it is essential that there be a diversity of opinion. It is because of doubt about an answer to a question that science and scientific research proceed. The moment that doubt vanishes, that part of science stops dead. The history of natural sciences shows us how many uncertainties which seemed to be resolved, later, on closer scrutiny, were shown to be uncertainties all the same.

The conscientious research worker is always reluctant to supply simple quantitative data. He is aware of the context within which such data are valid. It is his responsibility for the quality of his data that makes him hesitate to come up with precise values.

What he has to learn is to help the policy-maker to interpret these data in the right way. This implies that he should formulate precisely how far wrong he could

possibly be. He cannot and need not be a 100% certain. He will have to express his opinion, stating as accurately as possible the reliability of his results. The estimation of accuracy is an accepted part of scientific procedure. The given data should be formulated in such a way that the policy-maker knows what he is getting and what it is worth.

It is worthwhile mentioning that the model-makers explicitly introduce uncertainties into the presentation of their results.

In the relatively new field of environmental research this phenomenon is only too evident. The complexity of the problems that range far into the fields of sociology, psychology, medicine and all natural sciences, makes it difficult to give straight-forward answers to sometimes seemingly simple questions. But during this conference we have already heard a number of more precise values which according to the research workers will have to be minimum standards for quality or maximum values for pollutants. It is worth noting that the same applies to other fields of research and the application of the results, and that in those fields we have learned to live with this situation.

An engineer who has to build a bridge, design a building or lay down an airfield, carefully calculates his design, introducing all the data he needs concerning the materials and the construction to be used, including of course the data on the local situation of the site. Having done this he then multiplies the outcome with a factor 2 or 3 to be on the safe side, and then hands in his project.

This is quite opposite to the reaction of many who have to take decisions concerning the future of our environment. If the conclusion of a serious study results in a certain value to be reached in order to obtain an acceptable situation policy-makers tend to multiply by $\frac{1}{2}$ or even less. They do so as to obtain a value which conforms to what they believe could be done. It will be one that does not conform to the relevant data of the research.

The result is that quite generally the measures of control of environmental situations fall far behind the necessary minimum. The French have an appropriate expression for this way of thinking: "Après nous le déluge". It is because we are apt to let the short term facts prevail over the long term consequences.

In other fields of research on large scale problems, we find a similar situation. I take one example.

In economic studies considerable mistakes are being made because of inherent uncertainties in estimates of future developments. Ten years ago companies and governments invested millions in research on alternative energy resources: wind, solar energy, waves and tides, because of the rising oil prices. Now being taken unawares, and not forewarned by the economists, on a spectacular fall in oil prices, much of this initial research is being discontinued. It results in an deplorable waste of money and time, not to speak of the frustration of those who had put their minds on helping solve what seemed urgent problems. It is gratifying that at least some responsible people consider continuation of that kind of work worthwhile.

Now it is quite obvious that a long term policy for the environment can be based on very solid prognoses as compared to economic prognoses.

We know that the environment is seriously damaged by sulphurdioxyde, nitrogen-oxydes and hydrocarbons. We know that the emission of ammonia in some areas is a serious threat to plant life too. We know that all these substances can be reduced and we know that the more we reduce them the better are the expectations for the future. If you have listened to the papers presented here you must agree that this is a fair description of the situation. It is the message which the scientists here, assembled from a large number of countries from Europe and North America, have to give to the policy-makers. We trust the message will be understood and that the international cooperation for a clearly common interest will be promoted.

It is worthwhile to do something for the world we have in trust for future generations.