Acidic Deposition: Concern for the Future of Caspian Region

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Abstract: After almost three decades of intensive research on acidic deposition, it is still an important environmental issue in Europe and North America. Furthermore, anthropogenic emissions of the major pollutants involved _ sulphur dioxide (SO_2) and nitrogen oxides (NO) _ are increasing rapidly as industrialization proceeds and the use of fossil fuels increases in new geographical areas, including parts of eastern and southern Asia, southern Africa, and South America. These pollutants and their transformation products have long atmospheric lifetimes and can be carried by weather systems to distances of up to a few thousand kilometers from their point of emission. This causes acid deposition far from the primary source of pollution, thus making it a regional problem and an international transboundary issue. Considerable advances in the understanding of acidic emissions, transportation, deposition and consequent effects on ecosystems have allowed the development of the concept of "*Critical loads*", which has become an integral part of international negotiations aimed at controlling emission levels within Europe. Abatement strategies based on the critical load concept resulted in substantial decreases of acidic emissions, which have led to a lower degree of environmental degradation and even recovery in deposition. Some ecosystems in eastern Asia, where a regional acid monitoring network (EANET) is some ecosystems in eastern Asia, a regional acid already established implementation of some abatement strategies is under consideration.

Economic progress in the Caspian region is associated with an increase in the oil and gas production, industrialization and a higher demand for energy and food production. On the basis of previous experiences, such a progress will definitely lead to a considerable increase in emissions of acidifying pollutants. It is important that the environmental impacts of these emissions are estimated and taken into account in the planning process. The impact study is especially very crucial for the highly sensitive ecosystem of the southern Caspian watershed. If less polluting techniques are applied in the region, environmental problems, like those experienced in Europe and North America may be lessened. A rational strategy for limiting the adverse effects of acidifying pollutants should include consideration of *critical loads* and *critical levels*. So far, only preliminary estimates of *critical loads* are available for some parts of the region and there is a real need for regional research programs in this regard. Experience from policy actions, especially in the European region, could also be very useful for the Caspian states. There is, indeed, an obligation for environmental scientists to promote communication and cooperation with policymaking and decision-making sectors of the Caspian societies hoping that they can have better, if not the best, policy options to prevent further environmen-tal deterioration.

Introduction

The world is an acidic place, naturally. Most of the atmosphere has more acidic gases (e.g., C02, $S0_2$, NO, HCl, $HN0_3$) and particles (e.g., H_2S0_4), than basic gases (e.g., NH_3) and particles (e.g., $CaC0_3$). So, it is not surprising that wet deposition in terrestrial and marine regions remote from human influence is acidic. Most natural soils are acidic due to both organic matter production and decomposition, as are the headwaters that dram' from acid soils. Thus human activity is not making the world acid; rather it is making the world more acidic. In the last 100 years, the acidity of many regions of the world has increased as a consequence of energy and food production (Galloway, 2001). In the last 30 years, the phenomena and impacts of 'acid rain' have been extensively investigated in Europe, North America and Asia. This paper will give a brief historical overview of acid deposition, its main impacts on the environment and the important role of international cooperation strategies in establishing abatement strategies. Furthermore it will conclude by a look at the future of the Ccaspian Region in this regard.

Anthropogenic Acidification

Since the beginning of this century, accelerated rates of anthropogenic emissions of pollutants have led to a substantial increase in acidity of aerosol particles, cloud droplets, and precipitation in and around industrialized regions, particularly in Europe and North America. Enhanced, acidification of soil and water as well A & eutrophication (over enrichment through 'the deposition of nitrogen compounds) are environmental threats Which have significant adverse effects on many elements of both terrestrial and aquatic ecosystems. The impact on human health and material corrosion (predominantly stone decay which has been affecting Europe's heritage buildings and monuments) are other areas of concern.

The major pollutants involved are sulphur dioxide (SO_2), nitrogen oxides (NOx) and ammonia (NH_3). However, the full range would include sulphur species (SOx), oxidized nitrogen species (NOy), volatile organic compounds (VOCs), and ozone as well. 'Acid deposition' is the term used for the removal of the atmospheric pollutants of an acidic, or potentially acidic, nature whether they are deposited in rain or snow (wet deposition), as gases and aerosol particles (dry deposition), or in cloud droplet interception (occult deposition). The phenomenon of acid deposition (commonly identified term for acid rain) appears to have been discovered first by an English chemist -Robert Angus Smith - in the middle of the nineteenth century in Manchester (Cowling, 1982). Rainfall acidity measurements have revealed that precipitation is more acidic in industrialized regions of the world.

Diatom analysis of sediment cores obtained from numerous lakes provided clear and quite dramatic evidence of marked acidification of surface waters in the last several decades. The diatoms found in sediments can be used as a biological pH meter, indicating how the acidity of a lake has changed over time. Furthermore, the sediment studies also reveal that this modem-day acidification coincides in time with rising sediment levels of substances like heavy metals and soot particles which indicate pollution deposition deriving from the combustion of fossil fuels and from industrial emissions. Renberg and Hellberg 1982), for example, analyzed diatom assemblages in Lake Gardsjon sediment cores and found that the pH of the lake had decreased from about 7 to about 6 in the period of 12500 BC to 1950s due to natural long- term acidification. However, a more, marked decrease in pH values from 6 to around 4.5 occurred in the period of 1950s to late 1970s. Similar investigations in the UK (Battarbee et al., 1985), Norway (Berge et al., 1991), Sweden (Renberg et al., 1991) and North America (Charles, 1991) have revealed temporal trends in lake water pH in the post-1850 period in reaction to industrialization and increasing use of fossil fuels.

It is well established that the major impact of enhanced acidification, due to almost entirely anthropogenic activity, has been on freshwater ecosystems in the acidicbedrock regions of the northern hemisphere (Havas & Rosseland, (1995). On the other hand, the impact of acidification on terrestrial ecosystems is more controversial. The potential of acidic deposition to change the soil environment of trees is obvious, but one characteristic feature of the health condition of forest areas is the complex nature of pathological phenomena and the positive feedback of the negative results of action of many simultaneously occurring factors, both natural (droughts, winds, frosts, fires, insects, fungi etc.) and para-natural, the latter including chiefly emissions of environment-polluting substances that cause acidification and eutrophication of sites, toxic deposition of heavy metals and high concentration of troposphere ozone (Matzner and Murach, 1995). Where the concentrations of air pollutants are very high, the connection is clear. The, Europe-wide survey of leaf and needle losses in 1995 and 1996 revealed that 25% of the sample trees could be classified as damaged with a defoliation of more than 25 per, cent. The highest degree of damage has been found in Central Europe, namely in Poland, Czech Republic, Slovakia and eastern Germany, where local emissions of pollutants are substantially high (UN ECE, 1997). It is quite likely that even low concentrations of air pollutants or prolonged acidification of the Soil will tend to stress the trees and make them susceptible to damage from drought, frost, insect attack, etc. (Elingson, 1996).

In late 1960s, a Swedish soil scientist named Svante Oden hypothesized the broad ecological consequences of long-range transport of acidifying air pollutants based on measurements through Scandinavian network of surface water chemistry (Oden, 1968).

The international perspective of his findings and hypotheses had an important role in calling the world's attention to the phenomena and stimulation of further national and international research on identifying emission sources, pollutant deposition processes and patterns, acidification of ecosystems and source-effect relationships. Sulphur dioxide and nitrogen oxides are derived mainly from the combustion of fossil fuels in power stations, industrial boilers and motor vehicles. The major sources for ammonia, by contrast, are animal wastes and the application of fertilizers. These pollutants and their transformation products have, long atmospheric lifetimes and can be carried by weather systems to distances of up to a few thousand kilometers from their point of emission. This causes pollution acid deposition far from the primary source ofpollution thus making it a regional problem and an international transboundary issue.

International Cooperation and Abatement Strategies

Following the historical United Nation Conference in Stockholm in 1972, concerned with Human Environment and Air Pollution Across National Boundaries, a series of coordinated international conferences on the issue were held every five-year interval in Columbus, USA (1975), Sand Ford, Norway (1980), Muskoka, Canada (1985), Glasgow, UK (1990), Gothenburg, Sweden (1995) and Tsukuba, Japan (2000). At the conclusion of the 5 th acid rain conference, Rodhe et al. (1995) summarized what is being done to reduce the impact of acid rain. Responses of a temporary nature include the liming of surface waters and watersheds in Northern Europe. Solutions that are more permanent have also been adopted - emission reduction targets have been introduced on the national and international levels, primarily in Europe, North America and Japan. Since that meeting, China has also implemented reduction targets, which is one of the reasons why S02 emissions from China are planned to be significantly less in the future than those of projected to be in 1995 (Streets & Waldhoff, 2000). Although the emissions of sulphur dioxide have fallen generally both in Europe and North America and reduced fallout has recorded even in the so-called Black Triangle (the area of Central Europe where Germany, Poland and the Czech Republic converge), in many areas the depositions are still greater than nature can withstand. There are as yet no signs of any decline in the emissions of nitrogen oxides and ammonia the same can be said of the concentrations of low-level ozone, which is formed of nitrogen oxides and VOCs (Cemy & Paces, 1995). Furthermore, in, some areas of the developing world, such as east and southeast Asia, southern Africa and South America, recent industrialization has created major increases in pollutant emissions and acidity (Galloway, 1995). At the 6th acid rain conference in Tsukuba, Japan, it was concluded that acidic deposition problems in the region would become increasingly serious in the near future along with socio-economic developments in the region. The need for increasing international - cooperation was addressed and various monitoring network systems currently on-going and also those being planned, including the East Asian Monitoring Network (EANET), were introduced and comments were made on them (Satake et al. , 2001).

During the last few decades, considerable advances in the understanding of acidic emissions; transportation, deposition and consequent effects on ecosystems have allowed the development of the concept of *"Critical loads"* These are quantitative thresholds ,which help scientists and policyy-makers in their assessrnent of ideintifying areas most risk from continued deposition, while evaluating the impact of various pollutionreduction strategies, These thresholds are defined individually for particular pollutants and their receptors (i.e. water, soil, vegetation or materials), which once exceeded, will cause chemical changes leading to long-term harmful effects on ecosystem structure and Functioning (Henriksen et al., 1992). The definition of critical load adopted by UN ECE (1988) is: *"A quantitative estimate of exposure to one or more pollutants below which significant harmful effects on sensitive elements of the environment do not occur according to present knowledge "*. The term 'exposure' refers to a dose of pollutant deposition to a defined area over a specified time period and is expressed as deposition per unit area; *"pollutants"* refers mainly to atmospheric emissions of sulphur and nitrogen compounds; *"harmful effects"* refers to biotic aspects of ecosystems considering both direct or indect responses; and finally, *"sensitive elements"* may be chosen by individual countries ,likewise ecosystems or single species may be selected (Brodin & Kuylenstierna,1992). *"Critical levels"* (the thresholds for gaseous concentration exposures) have also been defined in a similar way.

Critical loads/levels have become an integral part of international negotiations aimed at controlling emission levels. Maps of critical loads for acidifying substances and the areas where the loads are exceeded play a vital role in deciding where and by how much, reductions need to be made. At 'European scale , pollutants are mapped at 150 km by 150 km grid scale (the European --Monitoring and Evaluation Program (EMEP) network) and in conjunction with land use, geology and vegetation, maps" of critical loads and exceedances can be drawn and the cost benefits of abatement measures explored. Abatement strategies based on the critical load concept require adequate deposition data on both local and regional scales. On the large-scale approach dealing with pollution deposition over Europe, the EMEP model has been considered as adequate for the quantification of transboundary exchange of pollutants (Lovblad et al., 1992). However, one problem of these large grids is that they mask a great degree of landscape heterogeneity.

Concern for the Caspian Region

Based on the experience gained in other parts of the world, the easiest projection to make for the Caspian Region is that in the future there will be more people who will need more food and use more energy. In addition, increases in per-capita resource use will mean that food and energy production will rise faster than population. This will result in an increase in SO_2, NO and NH_3 emissions to the atmosphere, which will result in increased deposition and acidification of the sensitive ecosystems. It is important that the environmental impacts of these emissions are estimated and taken into account in the planning process. The impact study is especially very crucial for the highly sensitive ecosystem of the southern Caspian watershed. If less polluting techniques are applied in the region, environmental problems, like those experienced in Europe and North America may be lessened. A rational strategy for limiting the adverse effects of acidifying pollutants should include consideration of critical loads and critical levels. So far, only preliminary estimates of critical loads are available for some parts of the region and there is a real need for common strategy in this regard. Experience from policy actions, especially in the European region, could also be very useful for the Caspian states. From a policy viewpoint we need better emission inventories; long-term measurements of atmospheric gas and aerosol species, and atmospheric deposition; and integrated monitoring of terrestrial and aquatic ecosystems. There is, indeed, an obligation for environmental scientists to promote communication and cooperation with policy-making and decision-making sectors of the Caspian societies hoping that they can have better, if not the best policy options to prevent further environmental deterioration. At the beginning of the 21 st century, it is our common recognition as well as resolution that we need to guard our environment. "A peaceful and beautiful green planet for our children in the coming centuries" is our earnest wish.

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