COPING WITH CRISIS IN EASTERN EUROPE'S ENVIRONMENT

EDITED BY
JOSEPH ALCAMO

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Preface

Along with the strong winds of political change in Central and Eastern Europe have come dirty winds of severely polluted air, as well as contaminated soil and water. Indeed one of the greatest challenges for Eastern Europeans in the coming years will be to cope with these urgent environmental problems during an already difficult transition period.

While much has already been said and written about environmental problems in Central and Eastern Europe, most of it has come from authors outside the region. But what do Eastern Europeans themselves have to say about the situation? This is one of the first books written since the revolutions of 1989 that gives the point of view of top environmental experts from the region. Represented are Bulgaria, the Czech-Slovak Federal Republic, Hungary, Poland, Romania, and the former Yugoslavia. In individual chapters of the book (Chapters 7 through 18), they critically examine the air- and water-quality situations of their countries. Much of the data and analyses contained in these chapters are being made available for the first time to an international audience.

Not only is the current environmental situation reviewed, but the book also presents many ideas for reforms and actions needed for coping with the environmental crisis in each country. These include specific suggestions for reforming the institutions and economic systems in these nations, as well as recommendations for technology transfer and training.

There are also several chapters with international themes (Chapters 1 through 6), including a review of existing Eastern European air-monitoring data, a report on transboundary air pollution in Central and Eastern Europe, and a review of nature conservation areas in the region. Of particular interest from the international perspective is Chapter 2 which presents the collective ideas of Eastern European experts on common problems and actions for environmental protection in the region.

Because of the impossibility of keeping pace with the rush of events in this part of the world, it is unavoidable that the book is already partly out-of-date. In particular, it was in production when the USSR and Yugoslavia were transformed into new states. However, rather than deleting chapters about these countries prepared before the changes, they have been included because they still contain much valuable data.

On the other hand, most of the text is rather current because authors were allowed to revise their manuscripts up to the autumn of 1991. Also, there is a Postscript (Chapter 19) by Tomasz Żylicz which brings the reader up-to-date on some topical issues about the politics and economics of environmental protection, which are not covered elsewhere in the book. In addition, much of the thinking about environmental protection in Eastern Europe presented in this book may be very relevant to the new republics of the Commonwealth of Independent States who are faced with a similarly daunting challenge to clean up their environment.

But nowadays environmental issues are overshadowed by the tragedy of violence in the Balkans, Transcaucasia, and elsewhere, and by the economic hardship troubling the entire region. In the face of this, two messages from this book stand out. The first is that nations of Central and Eastern Europe have many environmental problems in common, despite differences in geography and climate. The second is, contrary to the political forces that propel these countries apart, there are many opportunities for and advantages of cooperation in restoring their environment; there is hope that freedom, national pride, and regional environmental protection can go hand in hand.

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Acknowledgments

This book is based in part on an International Institute for Applied Systems Analysis (IIASA) Task Force Meeting on "The Environment in Eastern Europe" held in November 1990 in Laxenburg, Austria. (Most contributions, however, were updated in late 1991.) Experts from the following East European countries took part in the meeting: Bulgaria, the Czech-Slovak Federal Republic, Hungary, Poland, Romania, and Yugoslavia. In addition, experts from several international organizations (CEC, IIASA, Regional Environmental Center – Budapest, OECD, Vienna Center For Future Studies, Worldwide Fund for Nature) and other countries involved in East European environmental issues (Austria, Germany, the USA, and the USSR) attended the meeting. All participants are listed at the end of Chapter 2.

Credit for the success of that meeting is due, in particular, to Elisabeth Krippl and Judit Alberti for their excellent organizational work. The special contributions of chairmen and rapporteurs of working groups are also acknowledged: Ferenc Juhasz, Sten Nilsson, Kazimierz Salewicz, Helmut Schreiber, and Piotr Wilczynski. Results from the working groups were synthesized into findings which are presented in Chapter 2 in the form they were adopted at the meeting. Deserving special thanks are the participants who worked with the editor in drafting the findings of the meeting – they are George Djolov, Richard Liroff, and Piotr Wilczynski.

The chapters consist of contributions from both meeting participants and other experts. Results of discussions at the meeting are presented mostly in Chapters 1 and 2. The greater part of the manuscript was diligently revised for language by Aviott John. The editor is very grateful to him for his assistance. Credit is also due to Patricia Lichtenberg and Sabine Malek for their typing of the manuscript.

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The shaded area indicates Central and Eastern Europe as considered in this book.

Chapter 1

Introduction: Emergency Care for the East European Environment

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As Central and East European societies move into a new era of their histories, they drag along with them the environmental costs of their recent past. The damage is as diverse as the landscape: the once spectacular rapids of the Danube's Iron Gates in Romania are now impounded behind a 60-meter dam, and heavy metals collect in the sediments of the impoundment; the Bohemian forest of centuries-old legend now has the dubious distinction of receiving one of the highest atmospheric fluxes of acidifying sulfur in the world; a salt-mine in southern Poland serves as a fresh-air sanctuary for asthmatics because the air above is too difficult to breathe.

Since 1989 this urgent environmental situation has been attacked on many fronts and by many different kinds of organizations, from small citizen groups to national environmental ministries and international organizations such as the World Bank and the European Community. Among the accomplishments of these organizations have been the adoption of national environmental policies in both the Czech-Slovak Federal Republic and Poland, the establishment of numerous training programs with the West for environmental protection skills, and the founding of an information and education facility in Budapest (the Regional Environmental Center for Central and Eastern Europe). But despite these and many other accomplishments, it is becoming clear that nations in this region do not have the funds nor capability to cope quickly with the enormous scope and magnitude of environmental contamination – it seems that some difficult choices must be made about how to invest the limited resources available. One of the most urgent tasks, then, is to establish priorities of environmental protection. This chapter presents a few ideas that may be helpful in setting near-term priorities. These ideas are largely based on information presented in other chapters.

1.1 Problems Out of Focus

To set priorities for pollution control it is obviously necessary to critically assess the current situation, and this requires reliable and comprehensive environmental data. Unfortunately, there was a profound lack of these data until recently because previous regimes restricted their publication. Even today many data are not readily available. Another factor was the low priority given to implementation of environmental protection, and this led to overall neglect of monitoring and analysis of environmental problems. In addition, there has been, and continues to be, a lack of suitable equipment and trained personnel to obtain reliable data about environment quality. To illustrate the current deficiencies in data collection we take the present state of affairs in monitoring Poland's air pollution. Nowicki (Chapter 13) notes these deficiencies as:

- Non-standardized analytical and measurement methods.
- Lack of a national quality-control program for monitoring programs.
- Lack of high-quality measuring devices.
- Insufficient procedures and inadequate facilities for processing data.

We come to an obvious priority, one upon which other priority-setting depends – namely, good data. Specifically, there is need for environmental monitoring that is comprehensive enough for assessing and ranking environmental problems. Additional reasons for expanding monitoring programs are discussed in Section 1.2.

It should be noted that some comprehensive air-monitoring programs have been recently set up in Bratislava, CSFR, and Cracow, Poland. Others have existed for many years but are being upgraded, as in the case of Budapest. As a general rule, existing environmental monitoring systems need to have their measuring equipment, field procedures, and testing laboratories upgraded so that data collected are more complete and reliable.

1.2 What Is Known?

Because of the severity of environmental problems, there is tremendous (and justified) public pressure on authorities in Eastern Europe and in Western assistance organizations to select some priorities for environmental protection – even though, as pointed out in Section 1.1, there is a paucity of information to make informed decisions. What then do we know based on existing data that will help to set priorities? First of all, something can be said about the location of the most-affected areas and the most important problems in these areas.

The most intense environmental degradation occurs in several urban-industrial "hot spots," and there is growing agreement that the protection of public health in these areas should be the highest near-term environmental priority. It is difficult to specify the location and extent of hot spots in an objective way because, again, better data would be needed for the entire region. Nevertheless, some East European experts have made a first subjective accounting of these areas (Chapter 3). The amount of territory they classify as having very poor water quality adds up to 10% of the total area of six East European countries (Bulgaria, the CSFR, Hungary, Poland, Romania, and Yugoslavia). For air quality, this figure is 6%. These figures do not take into account other important measures of environmental quality such as the condition of the soil and vegetation, nor the amount of solid wastes, nor the incidence of environmentally related diseases; these data are even more scarce than water- and air-quality data.

Nearly every kind of environmental problem imaginable, except perhaps tropical deforestation, occurs in these areas. It is from here that the majority of anecdotes about ecological catastrophes in the region originate. Based on available data, the gravest problem in these territories seems to be the public-health risk caused by pollution. It is difficult, however, to assess the magnitude of this risk because reliable epidemiological studies are just being launched. Moreover, it is difficult to distinguish the effects of different pollutants from one another, and to sift out other influential factors such as the frequency of smoking and type of diet.

Nevertheless, the circumstantial evidence of public-health risks related to pollution is substantial. For example:

- Life expectancy in the CSFR is five to seven years shorter than in Western European countries; the infant mortality rate is 14.5 per 1,000 live births as compared to 9.1 in EC countries. The CSFR government relates this at least partly to environmental contaminants (Stoklasa, Chapter 9).
- Degraded air quality is presumed to play a role in the increased occurrence of asthma and bronchial diseases in Hungarian children, as well as the increased cases of adult bronchitis (Gajzago, Chapter 11).
- Children in the industrial city of Kuklem, Bulgaria, have levels of lead in their blood that are considered toxic in the West (Djolov, Chapter 8).

These assessments, together with plentiful anecdotal evidence, have led to a growing consensus that protection of public health should be the number one priority for environmental protection in the near term. This view is endorsed, for example, by environmental experts from six East European countries who have argued for "immediate assistance for hot spots because of the extreme risk to public health posed by pollution in these areas" (Chapter 2).

If this is the situation for the hot spot areas, what is the situation in the rest of the region?

A large part of Eastern Europe's area is rural, and environmental problems in these areas are of a different character than those in

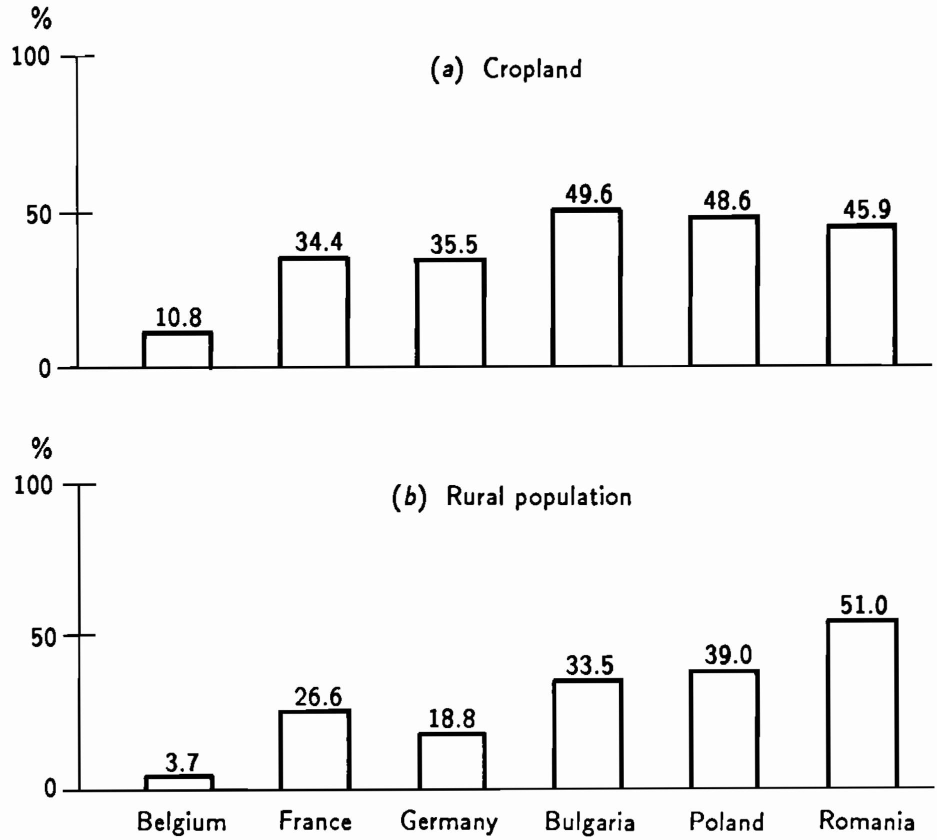

Figure 1.1. (*a*) Percent of cropland for selected Western and Eastern European countries; (*b*) Percent of rural population for selected Western and Eastern European countries.

urban-industrial areas. The information available on environmental problems in Central and Eastern Europe has left an image in some Western minds that the region consists of a long string of settlements and industrial agglomerations. But in reality much of the territory is rural and less densely settled in comparison with many Western European countries (*Figure 1.1*).

Environmental problems in these rural areas are generally of a more diffuse, long-term nature than those that occur in urban areas. Farming practices over the last four decades have led to soil erosion and loss of soil fertility; ground and surface waters have been contaminated by agricultural runoff containing nitrogen, phosphorus, and pesticides.

Forest resources have also been severely affected by logging practices and air pollution. For instance, as of 1986, it was estimated that 57% and 16% of the forests in the Czech and Slovak republics, respectively, had experienced some kind of forest dieback. This dieback has been circumstantially related to air pollution (Stoklasa, Chapter 9). In addition, many species of flora and fauna have become extinct because their habitat has been constrained or disappeared altogether (Karpowicz, Chapter 4).

Some public-health risks also occur in rural areas. For example, agricultural areas located in the vicinity of industrial air-pollution sources are contaminated by fallout from these sources. In Bulgaria, fallout from smelters contaminate some millions of hectares of agricultural land (Djolov, Chapter 8). Low-level contamination of crops distant from sources also occurs and is apparently due to long-range transport of pollutants (Alcamo, Chapter 6).

Among the most severely affected rural areas is the *Sulfur Triangle*, in the bordering areas of the Czech-Slovak Federal Republic, Germany, and Poland where forests are heavily damaged by high air concentrations and depositions of sulfur dioxide and other pollutants.

But, with the exception of the most heavily affected spots, the main environmental task in these rural areas is different from urban-industrial zones – namely, to conserve or restore existing natural and agricultural areas, rather than to protect public health. Since most countries in the region have large agricultural sectors, this also means the preservation of a large fraction of their economic base and of the rural hinterlands that provide food and sustenance to their cities.

Efforts to preserve biodiversity in the region can build on earlier efforts to conserve less-developed, natural areas. Indeed, large amounts of Eastern Europe's "natural areas" are already under protection, at least on paper. For example, 25% of Bulgaria's forests are protected, and 14% of the Czech Republic's total territory and 17% of the Slovak's total territory are also protected (Karpowicz, Chapter 4). At the same time, reforms are needed because many activities are permitted in these areas which can, and do, lead to a reduction in species habitat, such as logging, livestock grazing, and crop raising. The reduced military presence in some border zones has also provided an opportunity to expand the amount of protected areas, according to a concept entitled *Eco-bricks* which is being promoted by the Worldwide Fund for Nature and other groups (Anon, 1990).

Although the objectives of environmental protection may be different in rural and industrial areas, in both cases it is crucial to reduce the burden of pollutants to the air, soil, and water. The cost and time to accomplish this is the subject of the next point.

It will require substantial investments and take a long time for the burden of pollutants to be significantly reduced. Estimates of costs to reduce the burden of pollutants are as uncertain as other data. Nevertheless, appraisals of different kinds are beginning to give a consistent picture of the scale of investments that will be required. In 1990, the Minister of Environmental Protection, Natural Resources, and Forestry in Poland estimated the near- or medium-term costs required for environmental protection in Poland to be US$20 billion.[1] The national environmental policy document of Poland presents a figure of US$200 billion for the long-term investments necessary (Ministry of Environmental Protection, Natural Resources, and Forestry, 1990). These figures are not inconsistent with IIASA's estimate that the annual costs of a 70% reduction of Poland's sulfur dioxide emissions alone will be about DM3.9 billion (about US$2.4 billion).[2] These sums are rather daunting considering that the Polish gross national product in the 1980s was only about US$70 to 80 billion.[3] Taking an example from another country, the costs of necessary sewage collection and wastewater treatment in Hungary are estimated to be about US$5 billion (Somlyódy, Chapter 10).

As for solving problems in the region as a whole, IIASA has estimated that a 70% reduction of sulfur dioxide emissions will annually cost about DM16.8 billion (about US$8.6 billion).[4] These are the costs for reducing only one of a whole gallery of pollutants that are the typical targets of air-quality management plans such as nitrogen oxides, hydrocarbons, and heavy metals. Raising the enormous sums required for environmental protection will certainly delay any major program for environmental restoration in Eastern Europe.

Other factors will also contribute to the slowdown. For example, most East European countries are counting on the transition to a more efficient economy to reduce the burden of pollutants. For example, the Polish national environmental policy document says, "The achievement of significant results in environmental protection requires reconstruction of those spheres of the economy which present the main source of threat to the environment" (Ministry of Environmental Protection, Natural Resources, and Forestry, 1990). Similar sentiments were expressed by East European environmental experts at the IIASA Task Force Meeting on "The Environment in Eastern Europe: Sweeping economic reform is a prerequisite of successful environmental protection" (Chapter 2). Behind these policies is the sensible notion that the inefficiency of Eastern Europe's energy and industrial system has everything to do with the region's environmental problems. Proposals such as stringent energy conservation and conversion to natural gas provide ideas for medium- and long-term reductions of pollutants (Russell, 1991), but may not be able to serve as immediate remedies.

Related to this is the delay caused by the competition for funds for economic development. In many cases there are sound plans for restoration of the environment but inadequate financial support to carry them out. One case is Lake Balaton in Hungary where the steady progress made in reducing pollutant loads over the years has now been slowed because of lack of funds (Somlyódy, Chapter 10).

Another factor that will delay the cleanup in Eastern Europe is the current deficiency in every aspect of the environmental protection infrastructure in these countries. One example, already noted, is the grossly inadequate monitoring of the environment. Another is the inadequate maintenance of existing equipment. But there are also insufficient numbers of all kinds of environmental professionals and inadequate laboratory hardware, computers, and so on.

1.3 Emergency Environmental Protection

Considering the scale of investments necessary, the deficiencies in equipment and know-how, and the reliance on long-term economic transformations to take care of pollution reductions, it is likely to take two or three decades before the burden of pollutants will be significantly reduced in Central and Eastern Europe. Confronted with this reality, what then should be done in the next five to ten years with the limited funds and resources available for environmental protection?

Indeed some difficult choices must be made, of the sort that must be made in any emergency. With this in mind, one way to frame priorities for the next five to ten years would be to adopt a tactic of *emergency environmental protection*: The *immediate protection* of public health from the *greatest and most obvious environmental hazards*, using *readily available measures.*

In this definition *immediate protection* implies actions that can be taken in the next five years or so, and *greatest and most obvious environmental hazards* means that protective actions should concentrate on threats to public health that have already been identified (that is, do not need to be confirmed by epidemiological or risk-analysis studies). There are many examples of this: lead concentrations along many roads in Hungary often exceed health standards by several orders of magnitude (Gajzago, Chapter 11); in many parts of the Silesia region of southern Poland, the annual average sulfur dioxide level exceeds the WHO guideline (which is partly based on risk of respiratory disease) of 50 micrograms per cubic meter by a factor of three to four (see tabulated data in Nowicki, Chapter 13; WHO, 1987). However, it should be remembered that epidemiological or risk-analysis studies have an important role to play in sorting out pollution-control priorities for the medium and long term (next 5 to 30 years) when the burden of pollutants will continue to pose a risk to public health. But waiting for results from these studies should not delay immediate emergency actions.

The phrase *readily available measures* means reliance to the greatest extent possible (but not exclusively) on existing institutions, knowledge, and technology in Central and Eastern Europe. There is good professional expertise in the region in some environmental fields – for example, hydrologic studies in Hungary, air-pollution analysis in Poland, and forestry research in the CSFR.

Examples of some measures that follow from a policy of emergency environmental protection are:

- Implementing smog alarm systems similar to those found in some Western cities. These systems can reduce the exposure of city inhabitants to extremely high, but infrequent, air-pollution levels.

- Identifying and containing contamination from hazardous-waste landfills; containment is emphasized rather than cleanup, which is a later task. Indeed, in most countries of the region there are no facilities for detoxifying these wastes. Sofia, Bulgaria, for example, produces more than 168 tons per year of hazardous waste, but it is stored on-site for lack of treatment facilities (Sadovski, Chapter 7).
- Monitoring water supplies and providing emergency alternatives for supplies that are especially unhealthy. In many communities of the CSFR this is already done (Stoklasa, Chapter 9). In Hungary, 700 settlements must occasionally provide emergency water (Somlyódy, Chapter 10).
- Monitoring crops and food stuffs that are under high risk of contamination by pollutants (including, for example, crops in the vicinity of metallurgical plants); and taking administrative action to protect the public from this contamination.
- Identifying industrial facilities where there is a particularly high risk of accidental release of radiation or toxic chemicals and taking steps to reduce this risk.

1.4 An Example: Emergency Air Protection

These measures have the advantage of being *quick to implement, relatively inexpensive*, and *effective*. These traits are evident, for example, in the first measure listed in Section 1.3, smog alarm systems. Such systems, coupled with an emergency action plan, give the public a measure of protection from high levels of air pollutants that occur episodically. Because they do not involve permanent emission reductions, they cost much less and can be implemented more quickly than some other pollution-control measures. It is important to note that *they are not intended to replace permanent reductions of air-pollutant emissions* but are only a provisional measure until permanent reductions can be accomplished. They help protect the public because even in very polluted areas, dangerously high levels of air pollutants usually occur infrequently – only about 5% to 10% of the time within a typical year. For example, daily average sulfur dioxide levels in Zagreb, Croatia, are above the

WHO norm for health protection only during about 30 days in a year; this is equivalent to 8% of the year (UNEP, 1988). Recommended smoke levels are exceeded in Wroclaw, Poland, on 30 days in a year and on 17 days (5% of the time) in Warsaw (UNEP, 1988). These very high concentrations of pollutants usually occur when unusually high emissions coincide with unfavorable meteorological conditions. This happens, for example, during winter months in many East European cities when the burning of poor-quality coal for home heating releases large amounts of sulfur dioxide and soot that become trapped near the ground by temperature inversions.

With modern forecasting techniques, these events can be anticipated several hours before they occur; local authorities then have time to warn inhabitants with health problems to restrict their outdoor activity. More decisive action can also be taken, such as restricting traffic, requiring factories to use cleaner fuel, or, under extreme circumstances, closing down industries or restricting power production. While these actions cause some temporary hardship, they are by far quicker and cheaper to implement than installing permanent pollution-control devices on all major sources within polluted areas, or permanently closing down polluting factories. Most importantly, they can measurably reduce the exposure of inhabitants to dangerous levels of air pollutants. Many Western European cities have experience with warning systems, including most large cities in Germany as well as Milan and Vienna.

However, episode warning systems and other strategies for emergency environmental protection have the disadvantage of treating only the symptoms in many cases, rather than the causes of environmental problems. These are the basic inefficiency of industrial and agricultural systems, and the inefficient use of water, energy, and other resources in households, industries, and municipalities. The emergency measures described in Section 1.3 cannot substitute for the comprehensive economic, legal, institutional, and other reforms needed to deal with the region's problems. But to draw a medical analogy, emergency measures are never intended to rehabilitate a patient, only to buy time until longer-lasting treatment can be given. In the same way, emergency environmental protection can only buy time until longer-lasting measures can be taken.

1.5 A Regional Approach to Environmental Protection

The policy of emergency environmental protection addresses what should be done in the near term, but says nothing about how it should be done. Currently, each country is focusing on its own affairs, which is understandable since Central and East European nations should be expected to assert their newly found independence. In addition, countries know best about their own problems and how to fit the right solutions into their economic and political systems. At the same time, Western environmental assistance programs to the region have reinforced this country approach by delivering most of their support to individual countries rather than to the region. For example, the PHARE Program (Poland-Hungary Assistance to the Restructuring of Economies) coordinated by the European Community provided funds directly to Poland and Hungary in its first year and was expanded to include direct aid to Bulgaria, the Czech-Slovak Federal Republic, Romania, and Yugoslavia in its second year. The West has followed this policy partly for political reasons – not all nations in the region are perceived to be as far along in Western-style political changes – and partly for administrative reasons – not all environmental ministries are organized to the same extent to use this aid. On the other hand, there are some signs that a regional approach is being encouraged: it is reported that up to ECU 15 to 20 million will be spent in 1992 specifically for regionally oriented environmental programs. Indeed, the solutions of two classes of problems argue for strengthening such a regional, cooperative approach:

- *Common problems* that occur in nearly every country and could be solved by the same technology and know-how; for example, nitrate-contaminated groundwater, unidentified hazardous-waste disposal sites, and inadequate water- and air-monitoring systems (Chapter 2).
- *Transboundary problems* that no individual state can solve alone; for instance, sulfur and photochemical oxidant air pollution, illegal transport of hazardous materials, and pollution of international rivers (see Chapters 2 and 6).

A regional approach could be realized in the form of a "Regional Action Plan for the Environment in Central and Eastern Europe." The plan should designate specific areas of cooperation on common and transboundary problems in the region. There is every indication that Western assistance organizations would look favorably upon such a plan because it would help minimize the duplication of cleanup efforts in different countries and it would provide an opportunity to make the widest use of limited funds for environmental protection.

The initial plan should be divided into two parts: (1) technology and expertise needed from the West for emergency environmental protection and (2) actions that countries in the region could take without substantial Western assistance. Items in the first category could include:

- Equipment for monitoring the quality of water supplies.
- Equipment for real-time monitoring of air quality in urban-industrial areas.
- Technology and equipment necessary for assessment of hazardous waste and hazardous materials.
- Equipment necessary for monitoring contamination of foodstuffs.
- Training for design and operation of monitoring systems, and conducting epidemiological studies.

In the second category, the plan could include:

- Development of an environmental code for investments from outside Central and Eastern Europe to prevent economic development from further degrading environmental quality. It is crucial for all countries in the region to agree on this because a single country with lower environmental standards (and thereby lower pollution-control costs) might attract Western investment at the expense of other countries. Such a code of conduct is currently being discussed by the European Community and individual countries.
- A regional plan for the management of hazardous wastes together with an agreement on the illegal or legal international transport of hazardous wastes. A recognized priority in the region is the identification and regulation of hazardous materials and wastes (see Chapter 2, for example). One aspect of this problem is the need to regulate the transport of these wastes across borders in the region.
- A regional plan for the Sulfur Triangle, where high levels of air pollution cause numerous environmental problems.

These are just a few possible ideas for the content of a regional action plan. But above all, the plan should be realistic; it should take into account the current status of relations between countries in the region and therefore be modest in scope, at least at the outset. Nevertheless, there is some evidence of political support within Eastern Europe for such regional cooperation. Within the last two years, for example, East European environment ministers have called for a regional approach to environmental protection at their Bergen, Norway, and Poznań, Poland, meetings. Moreover, efforts to control waste loads to the Baltic Sea are moving along rapidly. Another positive example is presented by the Regional Environmental Center for Central and Eastern Europe in Budapest, which coordinates a very active regionwide program of environmental education and transfer of expertise. The goal of the Center, as should be the goal of any regional plan, is to develop the expertise of Eastern Europeans themselves to cope with their region's environmental problems.

Above all, there are strong financial arguments for a regional action plan – for East European countries it may provide an opportunity to obtain funds for environmental protection over and above what they now receive by means of existing bilateral programs. For the West, as already noted, it is a way to avoid duplication of effort and to broaden the effectiveness of currently limited environmental assistance.

The success of a modest regional action plan could conceivably lead to a larger "Ecological Marshall Plan for Central and Eastern Europe," which could focus on medium- and long-term priorities for environmental protection. The original Marshall Plan of the 1940s encouraged nations to agree on common priorities despite their initial resistance to do so.

Regional cooperation can also take forms other than a regional action plan. For instance, two countries that share environmental problems in a border area could have overlapping sections in their national environmental policy documents. These sections would describe the mutual commitment of both countries to address transboundary problems along their borders, and would be a very positive foreign-policy gesture. For example, both the Polish and Czech-Slovak national environmental policy documents emphasize the need to deal with pollution problems on their border areas in the Sulfur Triangle and in the High Tatras (Ministry of Environmental Protection, Natural Resources, and Forestry, 1990;

Ministry of Environment of the CSFR Commission for Environment, 1990). Future versions of these documents could contain a negotiated common statement of objectives regarding these border areas.

Another product of a regional approach could be a "Regional Environmental Training Academy" with branches in each country. Individual countries would host a branch which provides training in areas of their special technical strengths. For example, Hungary might host training in water-quality analysis; the CSFR in forestry studies; Poland in air-pollution management.

Much can be done and must be done in restoring the environment in Central and Eastern Europe. This chapter has presented a modest few ideas for priorities; the remainder of the book presents additional proposals for actions. As to the prospects for regional cooperation, there are admittedly strong centrifugal forces pushing nations in Central and Eastern Europe away from one another and from themselves. But there are also forces contrary to this. These nations have a common 40-year legacy of central planning, heavy industry, and so on, which has led to urgent and common environmental problems. During this 40-year period there were also cases of genuine regional cooperation. Moreover, these nations share a common atmosphere and many common waterways. In this new era, when there is much to do but few resources to do it, the idea of mutual environmental assistance is a compelling notion.

Acknowledgments

This article was based in part on ideas presented and generated during the discussion and working groups of the IIASA Task Force Meeting on "The Environment in Eastern Europe," November 1990. Participants of this meeting are listed at the end of Chapter 2. The author acknowledges the experts who took part in that meeting and shared their ideas. He is also indebted to Barbara Lübkert-Alcamo and Meinhard Breiling for reviewing this manuscript.

Notes

[1] Minister Kaminski made this remark during a 1990 visit to the United States. The period he was referring to was about 10 to 15 years.

[2] Taken from RAINS model calculations, Version 5.1 (Amann, 1990; Alcamo *et al.*, 1990).

[3] WRI (1988), for example, presents an estimate of US$77.7 billion for 1986.

[4] Calculations take into account the following countries: Albania, Bulgaria, CSFR, Hungary, Poland, Romania, Yugoslavia, and the former East Germany (Amann, 1990; Alcamo *et al.*, 1990).

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Chapter 2

The Environment in Eastern Europe: Common Problems and Corrective Actions in the Region

IIASA Task Force on the Environment in Eastern Europe
International Institute for Applied Systems Analysis
Laxenburg, Austria

From 19 to 23 November 1990, the International Institute for Applied Systems Analysis (IIASA) convened a Task Force meeting in Laxenburg, Austria, on critical issues regarding the environment in Eastern Europe. Experts from six East European countries (Bulgaria, the Czech-Slovak Federal Republic, Hungary, Poland, Romania, and Yugoslavia), as well as representatives from Austria, Germany, the USA, the USSR, and several international organizations, took part in the meeting.[1] This chapter presents the statement adopted by the Task Force regarding problems *common* to most or all countries in Eastern Europe and priorities for *near-term* corrective actions throughout the region.

2.1 Common Environmental Problems in Central and Eastern Europe

Central and East European (formerly socialist) countries, despite their diverse climatic and natural conditions, suffer from many common environmental problems. Acute pollution of air, water (surface and ground), and soil occurs in many locations throughout the region. Inhabitants of cities are frequently exposed to extremely dangerous levels of pollutants emitted by the aging and poorly controlled transportation fleet, as well as domestic and industrial sources. Perhaps the most striking example of environmental contamination is the Sulfur Triangle where the Czech-Slovak Federal Republic, Germany, and Poland meet. This region has experienced substantial forest decline with consequences for stability of the landscape and water balance. Acidified soils have made reforestation difficult. Throughout the region, air pollution is caused by high levels of emissions of SO_2, NO_x, CO, and dust coming mainly from obsolete thermal power plants burning low-quality coal and from heavy industry (especially metallurgical and chemical).

Surface waters are intensely polluted. Most are not usable for drinking nor, in many cases, for industrial and irrigation purposes. Common sources of pollution include untreated municipal and industrial wastewaters. Water shortages are common because of overuse and contamination of water sources. Atmospheric deposition further intensifies the water-pollution problem.

Improper agricultural practices and collectivized animal farms (feed lots) influence the fertility and quality of soil, accelerate its erosion by water and wind, and disturb the ecological stability of landscapes. Many species of flora and fauna have become extinct or are threatened with extinction. Loadings of nitrogen and phosphorus compounds, pesticides, organic chemicals, and bacteria move through ground and surface waters and poison the food chain.

Soils are used as dump sites and collect the pollutants that have traveled through air and water. There is an appalling lack of knowledge about the location, amount, and toxicity of dumped wastes. Modern facilities for the environmentally sound management of municipal and industrial solid and hazardous wastes are virtually nonexistent.

Higher-than-average occurrences of birth defects, learning disabilities, respiratory diseases, shortened life spans, and other health effects have been reported in heavily contaminated areas. Throughout the region, monitoring of air, water, and soil is grossly inadequate. Moreover, analytical methods are sometimes incompatible; there is a general lack of comprehensive, quantitative information about pollution levels. Nevertheless, existing information is sufficient to identify hot spots that most deserve immediate response, although improved monitoring is necessary to formulate the most cost-effective solutions.

The transboundary transport of pollutants among the countries of this region and between this and other regions has been clearly demonstrated.

2.2 Socioeconomic Causes of Environmental Problems

The major environmental problems of Central and Eastern Europe are rooted in the socioeconomic structure of the past 45 years. This structure's major characteristics have included state ownership, central planning, unrealistic pricing, obsolete and inefficient industries, nonenforcement of environmental laws, and indifference to environmental concerns by state authorities. In addition, public participation was prevented and state environmental data were often kept secret. State-owned enterprises have been poorly managed and upkeep has been insufficient. Together these have resulted in wasteful production processes.

Currently, institutional structures for environmental management are fundamentally inadequate. Legal instruments are not sufficiently developed and implemented. In most countries environmental agencies are underfunded and the skills of their personnel require upgrading. The past failures to inform the public adequately about the environmental situation have sometimes caused newly emerging environmental movements to confront state agencies. Educational systems have failed to incorporate environmental concerns into their curricula.

2.3 Near-Term Priorities for Corrective Actions in Eastern and Central Europe

Considering the severity of these environmental problems, it is important to divide plans for corrective actions into near- and long-term priorities. This chapter refers only to *immediate-* or *near-term* (three to five years) priorities for corrective actions.

2.3.1 Economic reform and environmental protection

Sweeping economic reform is a prerequisite for successful environmental protection. Key elements of the required economic reforms include: privatization and private property rights; real pricing of natural resources and energy; restructuring and modernizing of industry; and eliminating state subsidies of industry. As demonstrated in the West, unregulated markets alone cannot protect the environment. Therefore, both administrative and economic instruments, as well as regulations and their enforcement for environmental protection, are necessary for economic reform. If economic reform occurs slowly or not at all, then the quality of environment in the region will continue to deteriorate with all of its consequences.

2.3.2 Institutional upgrading and development

The existing environmental management system of the countries in the region needs to be reviewed and changed.

- New national environmental management systems should be based on integrated environmental management that promotes the comprehensive analysis of hazards in air, water, and soil so that these hazards are reduced, rather than shifted from one medium to another. Integrated environmental management also favors prevention of pollution over end-of-the-pipe controls.
- Overall responsibility for national environmental policies, standard setting, national monitoring systems, and international cooperation should be assumed by the ministry of environment (federal or national) in each country. To complement these national-level activities, states should assign management and enforcement of

environmental laws and standards, as well as financing schemes, to lower levels of government and to regional bureaus of national ministries. The efficiency of all levels of government must be increased by upgrading and strengthening the skills of their staff. This can be accomplished by *twinning* programs with foreign counterparts, study tours in foreign countries, workshops, seminars, and other educational activities. Efficiency can also be improved with the advice of foreign consultants and by establishing policy working groups and interdepartmental working groups. Government offices also require better telecommunications equipment such as personal computers, copying machines, and telefax machines.

- There is the need to improve and supplement the command and control policies of government with economic instruments to change the behavior of polluters. Assistance should be given to work out financial schemes for environmental protection. This should be treated as an integral part of a new environmental management system.
- The existing national monitoring systems for the environment need to be upgraded, expanded, and redesigned. This activity should be accompanied by the development of information systems useful for decision making. The European Agency for Environment, for which countries in the region have expressed an interest, could play an important role in this aspect.
- Special centers for resolving conflicts arising from environmental issues should be established.
- The organizing of private consulting firms specializing in environmental problems should be encouraged.
- New institutions are needed to conduct policy research in support of the ministry of environment.

2.3.3 Environmental regulations and enforcement

A key part of the new environmental management system in the region should be the drafting of new environmental legislation that progressively adopts the environmental standards and regulations of the European Community and other Western countries. These regulations should include procedures for environmental impact assessment of new developments.

As past experience in the region demonstrates, even the most carefully designed system for environmental protection (including administrative mechanisms and economic instruments) will not be successful if not enforced. Enforcement programs must be fully funded and personnel adequately trained and equipped.

2.3.4 Economic instruments for environmental protection

The *polluter pays* and *user pays* principles should be adopted in the countries of the region. Pollution charges, environmental taxes and funds, and administrative instruments should be introduced to internalize social costs and provide a method for influencing polluter behavior. These economic instruments should take into account the scarcity of certain natural resources. Pollution charges and other incomes should be used at the government or administrative level where they are collected.

2.3.5 Environmental education and public awareness and participation

Environmental instruction should be included at all levels of education and professional training. Public awareness should be raised by the appropriate dissemination of information. Mass media can play a special role here.

Strong public support is needed for environmental protection measures. This requires public access to data and other information about the environment, as well as participation in environmental impact assessment and public-policy development. Nongovernmental organizations (NGOs) have a key role to play in educating the public, promoting public participation, and holding governments accountable. Western NGOs and foundations should support the emerging NGOs in Eastern and Central Europe to enhance their future effectiveness.

The development of science and technology should be focused on their application to practical problems.

2.3.6 Air-quality problems

An effective institutional system for air-quality management is needed. This system should include an air-quality monitoring network, together with the capability for smog prediction.

The principal aim of air-pollution control in the near term should be the protection of public health, especially in hot spots. Investments in pollution control should target economically viable enterprises. Near-term priorities for corrective action include: energy conservation (pricing policies, fuel switching, energy and environment audits), particulate control on large point sources in the vicinity of settlements, improvement of safety at nuclear-generation facilities, and where appropriate use of nontraditional energy sources (for example, solar water heating).

2.3.7 Water-quality problems

An effective institutional system is also needed for water-quality management. Again the near-term goal should be to protect public health. Because of the scarcity of potable water it is recommended that water conservation be an important near-term strategy. Other important measures include reducing untreated municipal sewage, cleaning up toxic hot spots, and reducing the use of pesticides and nitrate fertilizer in agriculture.

Investments in water- and wastewater-treatment facilities should concentrate in the near term on nearly completed facilities. Special attention should also be given to maintain and operate existing facilities.

2.3.8 Waste management

Existing institutional systems should be upgraded and expanded especially for toxic and nuclear wastes. The following measures should be given priority:

- Halting the illegal transport of hazardous wastes between countries.
- Retaining and improving existing recycling systems.
- Setting up an inventory of wastes not currently inventoried (for example, toxic wastes) and identifying hot spots.
- Cleaning up hot spots of greatest danger to public health.

2.3.9 Soil, landscape, and nature protection

Economic incentives and planning are necessary to encourage new agricultural practices (including the reduction of pesticides and fertilizers) that are necessary for preventing additional degradation of soil and for promoting the stability of the landscape. Special attention must be given to reforesting damaged areas.

In the near term, the highest priority should be given to preserving natural areas not yet officially protected (such as border areas). The possible environmental impact of any development in these areas must be carefully studied. In the hot spots of air, water, and soil pollution, emphasis should be given to restoration of the natural environment. However, this should not be viewed as a substitute for pollution control.

2.3.10 Transboundary pollution

Countries in the region should intensify their cooperation in developing medium- and long-term pollution-abatement plans for shared water and air resources. This cooperation should take into account existing frameworks for collaboration in Europe.

For water resources, this includes the Black and Baltic seas, and the Odra, Vistula, Elbe, and Danube rivers. For air resources, this is especially important for the Sulfur Triangle.

2.3.11 Accident prevention and response

Attention should be taken to prevent hazardous industrial accidents. National and international plans should be developed to minimize the risks of these accidents and to respond to them when they occur.

2.4 Foreign Aid and Regional Cooperation

The priorities outlined in Section 2.3 require international assistance and support. In particular, immediate assistance is needed for hot spots because of the extreme risk to public health posed by pollution in these areas.

The following organizations can play an important role in providing this international assistance: Commission of the European Communities, European Bank for Reconstruction and Development, European Environmental Agency, European Investment Bank, Food and Agricultural Organization, International Atomic Energy Agency, International Energy Agency, International Institute for Applied Systems

Analysis, International Union for the Conservation of Nature, Nordic Bank, Organisation for Economic Co-operation and Development, Regional Environmental Center, UN Development Programme, UN Environment Programme, World Bank, World Health Organization, World Meteorological Organization, and Worldwide Fund for Nature.

Of the preceding priorities, the following items require cooperation within the region:

- Developing plans for controlling transboundary air and water pollution.
- Organizing a system for the inventory of wastes.
- Controlling the illegal transboundary transport of toxic waste.
- Standardizing the licensing of new products.
- Establishing an environmental code of conduct for Western investments.

Note

[1] Participants in the IIASA Task Force Meeting on Environment in Eastern Europe include:

Austria – Konrad Zirm, Ministry of the Environment, Vienna.
Bulgaria – Petar Beron, Academy of Science, Sofia; George Djolov, Institute of Ecology, Sofia; Alexander Sadovski, Institute for Environmental Research and Information, Sofia.
Croatia – Velimir Pravdić, Center for Marine Research, Rudjer Bošković Institute, Zagreb.
CSFR – Ladislav Miklós, Slovak Commission for the Environment, Bratislava; Jaroslav Stoklasa, Commission for the Environment, Academy of Sciences of the CSFR, Prague.
Germany – Hans-Joachim Hermann and Michael Nowak, Federal Environmental Agency, Berlin.
Hungary – László Gajzago, Ministry of Environmental Development, Budapest.
Poland – Marek Roman, University of Technology, Warsaw; Piotr Wilczynski, Ministry of Environmental Protection, Natural Resources, and Forestry, Warsaw.
Romania – Teodor Ognean and Angheluţă Vădineanu, Ministry of the Environment, Bucharest.

Russia – A. Bazykin, Committee on Environmental Protection, Moscow; Felix Ya. Rovinsky, Committee for Hydrometeorology, Moscow; Alexander Zaitsev, Geophysical Observatory, St. Petersburg.
Yugoslavia – Zorka Vukmirović, Institute of Physics, Belgrade.
International organizations – Helmut Schreiber, Institute for European Environmental Policy, Bonn, Germany; Philippe Bourel de la Ronciere and Sylvie Motard, CEC, Brussels, Belgium; Ferenc Juhasz, OECD, Paris, France; Peter Hardi, Janusz Kindler, and Steve Wassersug, Regional Environmental Center for Central and Eastern Europe, Budapest, Hungary; Prince Alfred von Liechtenstein, Center for Future Studies, Vienna, Austria; Richard Liroff, Worldwide Fund for Nature, Washington, DC; Joseph Alcamo, Sten Nilsson, Kazimierz Salewicz, and Friedrich Schmidt-Bleek, IIASA, Laxenburg, Austria.

Chapter 3

A Geographic Overview of Environmental Problem Areas in Central and Eastern Europe

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Along with the wide variety of information now available on environmental problems in Central and Eastern Europe has come the need for a geographic perspective on the extent of these problems. This chapter attempts to provide this perspective based on information from environmental experts in the region.

Participants of the IIASA Task Force Meeting on "The Environment in Eastern Europe" (Chapter 2) were asked to rank subjectively either water or air quality (depending on their expertise) within their respective countries according to the following simple scheme: grade 1 – very good; grade 2 – good; grade 3 – medium; grade 4 – poor; and grade 5 – very poor.

Unfortunately, it was considered unrealistic to set objective criteria for the ranking. To do so would have required much more detailed, comprehensive, and accurate environmental data than were available. While there is a flood of information on the environment in Eastern Europe, the reliability of many of these data is in doubt. Moreover, there is still no agreement in Europe, or elsewhere, on which pollutants are the best overall indicators of environmental quality, although major work on this subject is now being carried out (for example, at the Environment Agency Task Force of the European Community in Brussels and in the Environment Directorate of the OECD in Paris). Indeed, because the types of water- and air-quality problems vary significantly from location to location, the indicators of these problems may also vary.

There are other complicating factors, such as the possibility that two or more pollutants have synergistic effects. There is also the question of which environmental effects should be considered most important. For water quality, is it the disappearance of fisheries or enhanced risk to public-water supplies that is most important? All things considered, it was outside the scope of the present effort to produce more than a subjective ranking of quality for the entire region.

The experts were asked to assign a grade to the subareas covered by a grid of their country. For this purpose the OECD/EMEP European grid was used because it is internationally accepted for organizing air-emissions data. It also has a reasonable spatial resolution (50 km $\times$ 50 km) considering the large region we wished to cover.

The grades for air and water quality were based in almost all cases on the subjective weighting of different pollutants. An exception was the ranking of air quality in Poland, which was related to annual average measurements of sulfur dioxide throughout the country in 1989. The category of medium air quality corresponds to 16 to 32 micrograms per cubic meter. Another exception is the map of water quality in Poland which is based on a map of river water quality published in *Basic Monitoring: Report on Water Quality of Rivers Measured in 1990.* This report was published by the Institute of Meteorology and Water Management, Wroclaw, in 1991. It should also be noted that all assessments refer to both urban and rural areas.

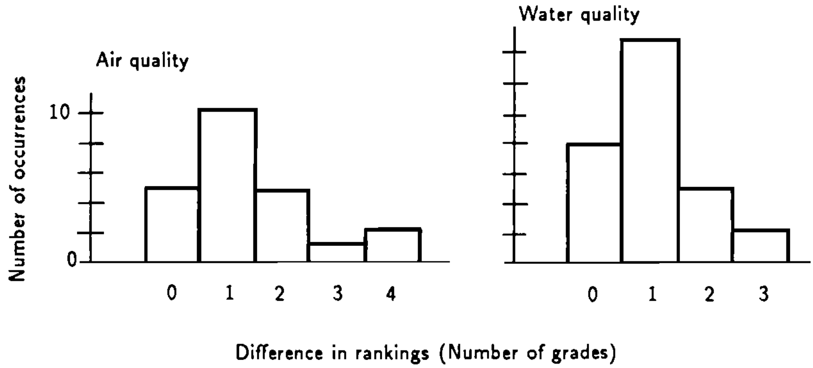

Figure 3.1. The difference in ranking assigned by two different experts for the same border grid squares. The sample size for air quality and water quality is different because some experts did not assign a ranking for environmental quality in some border squares.

3.1 Consistency of Different Experts

The validity of a subjective exercise such as this obviously depends on the consistency of the different experts in assessing environmental quality. This can be checked simply by comparing the rankings given by experts from different countries to the same grid squares along borders. However, in many border grid squares the portion belonging to a particular country was so small that experts from these countries did not bother to assign a ranking. This was the case in 40 of the 63 border grid squares for air-quality ranking. In two out of three of the remaining squares, the grades assigned by air-quality experts from different countries were either identical or differed by only one grade (*Figure 3.1*). In one out of three cases the differences were greater.

There was even closer agreement between water-quality experts; their rankings for the same border grid squares either were identical or differed by only one grade in three out of four cases (*Figure 3.1*).

(Water-quality data from Poland were not available when this analysis was performed.) Although some disagreement can be attributed to different subjective rankings of the experts, some of it is consistent with reality – one side of the border may have greater environmental problems than the other side.

3.2 Results for Individual Countries

Results of environmental quality ranking for six countries are presented in *Figures 3.2* to *3.13*, and are summarized in *Table 3.1*. The amount of area assigned a grade 5 air quality (very poor) ranged between 0% and 20% depending on the country. The area with grade 5 plus grade 4 (poor plus very poor) ranged between 5% and 46%. Hungary had the smallest area in these two categories and the CSFR, the largest.

Table 3.1. Percent of area in two worst categories of environmental quality.

	Air		Water	
Country	Grade 5	Grade 4+5	Grade 5	Grade 4+5
Bulgaria	14	26	0	9
CSFR	20	46	26	53
Hungary	0	5	5	19
Poland	2	14	17	37
Romania	5	20	8	22
Yugoslavia	3	11	0	4
Eastern Europe	5.8	18.6	9.7	24.1

For water quality, the amount of area in the worst grade ranged between 0% and 26% for different countries. The area having both grade 4 plus grade 5 ranged between 4% and 53%. Again the CSFR had the largest area in these two categories; Yugoslavia had the smallest area.

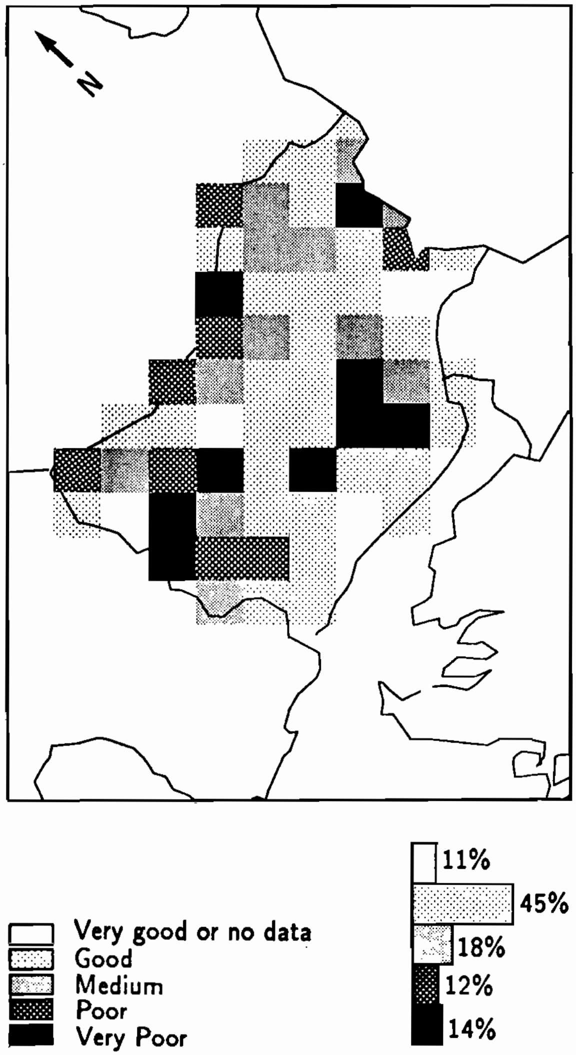

Figure 3.2. Air quality in Bulgaria.

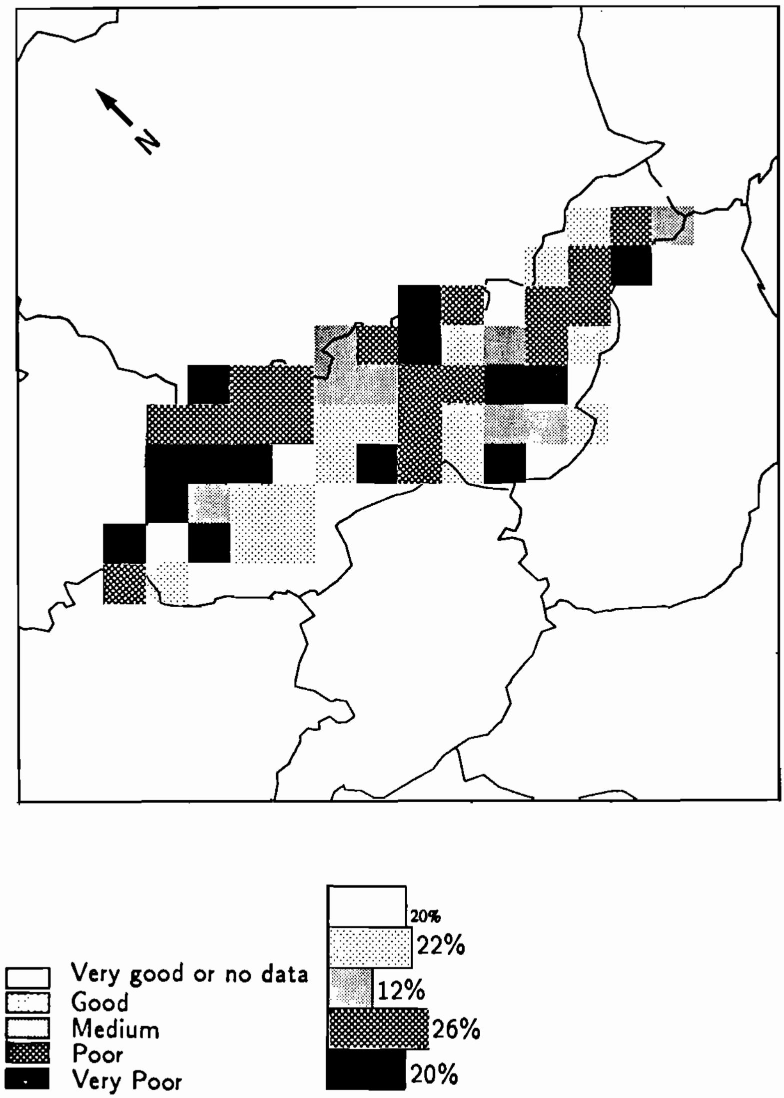

Figure 3.3. Air quality in the CSFR.

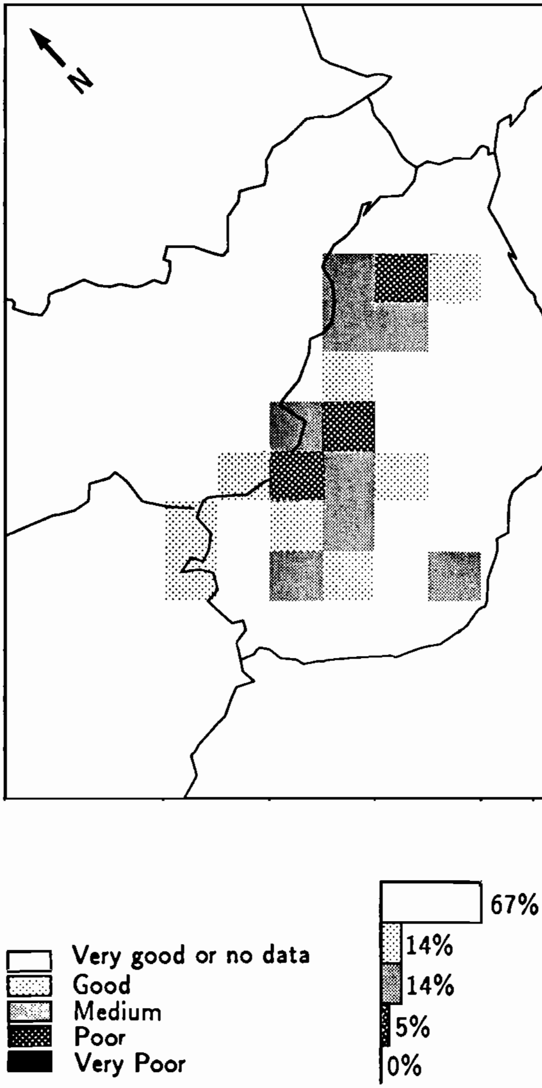

Figure 3.4. Air quality in Hungary.

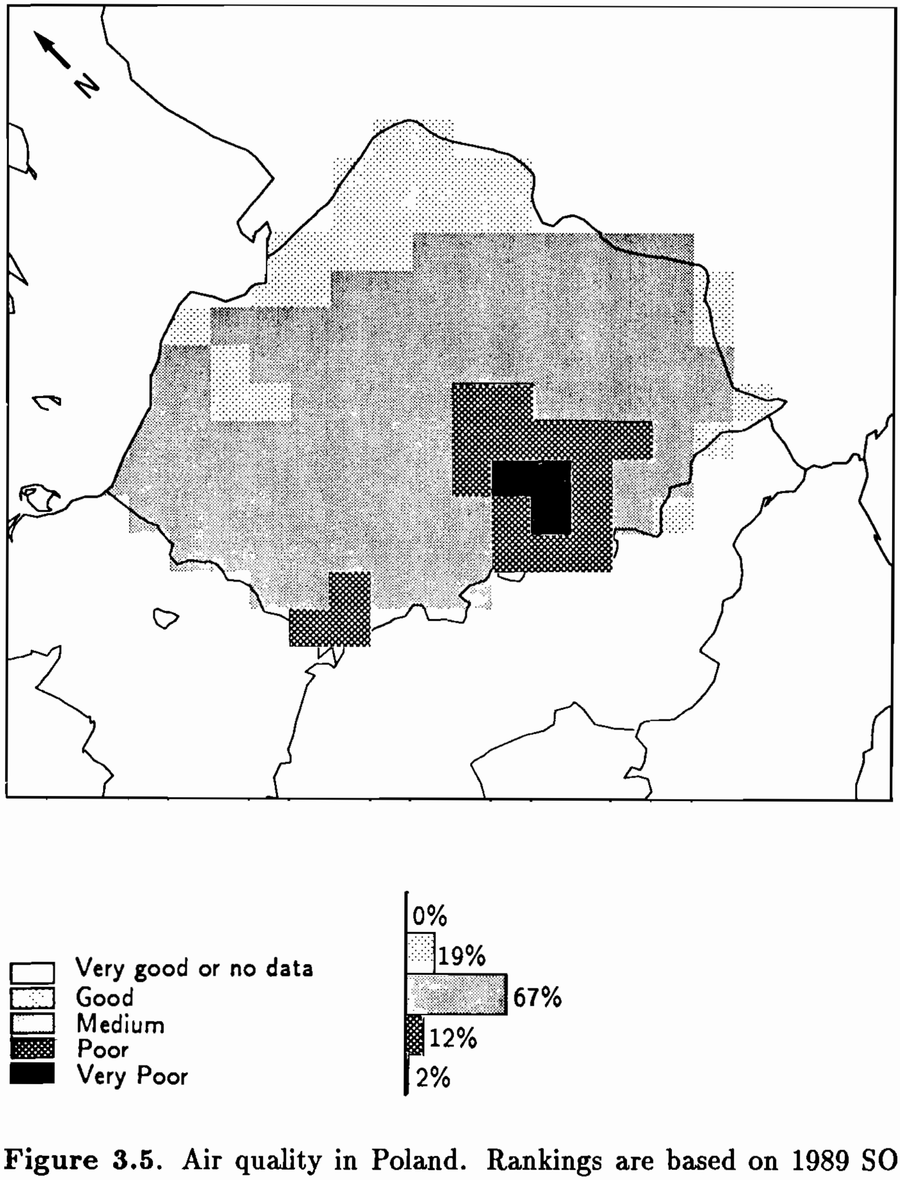

Figure 3.5. Air quality in Poland. Rankings are based on 1989 SO_2 levels. "Medium" air quality corresponds to an SO_2 concentration of 16 to 32 $\mu g\ m^{-3}$.

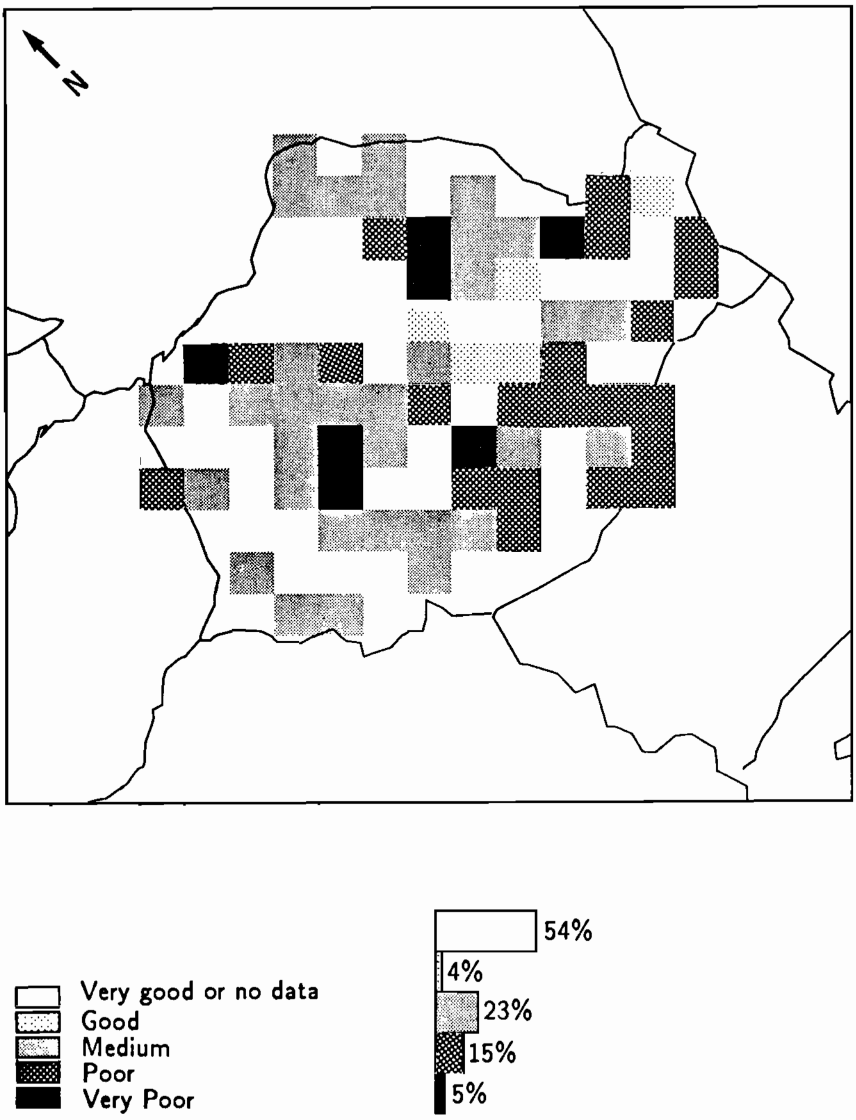

Figure 3.6. Air quality in Romania.

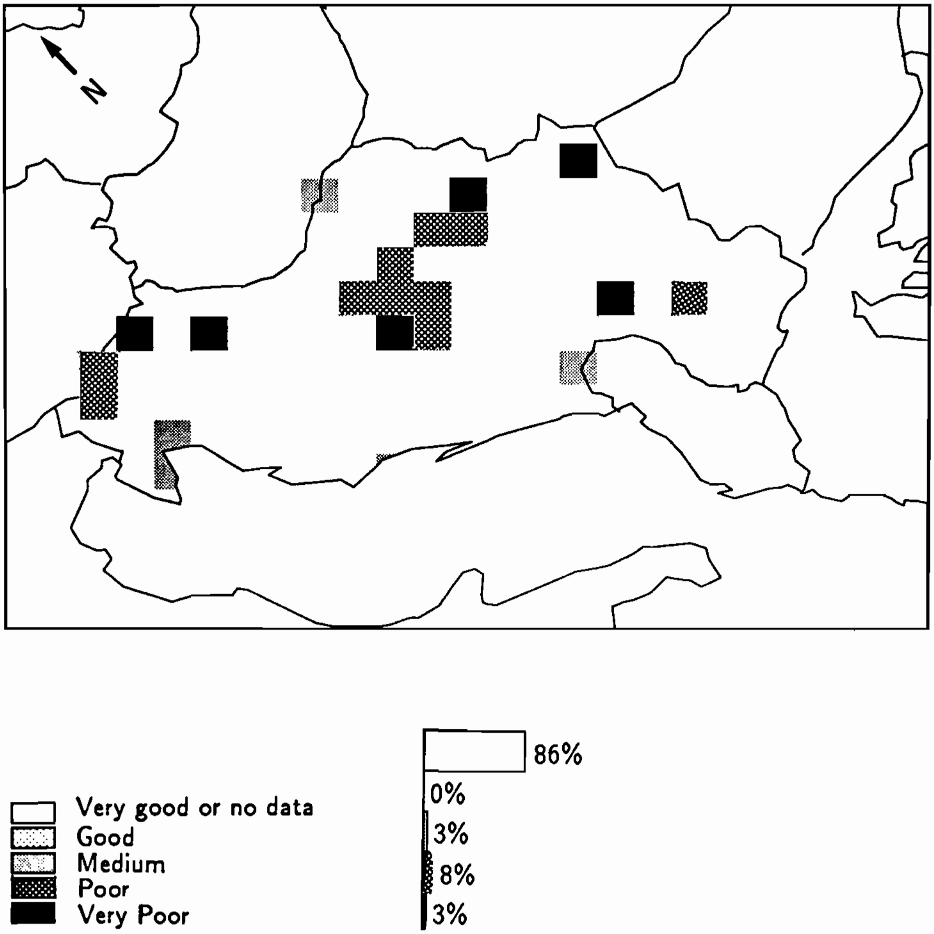

Figure 3.7. Air quality in Yugoslavia. (This map was prepared before mid-1991.)

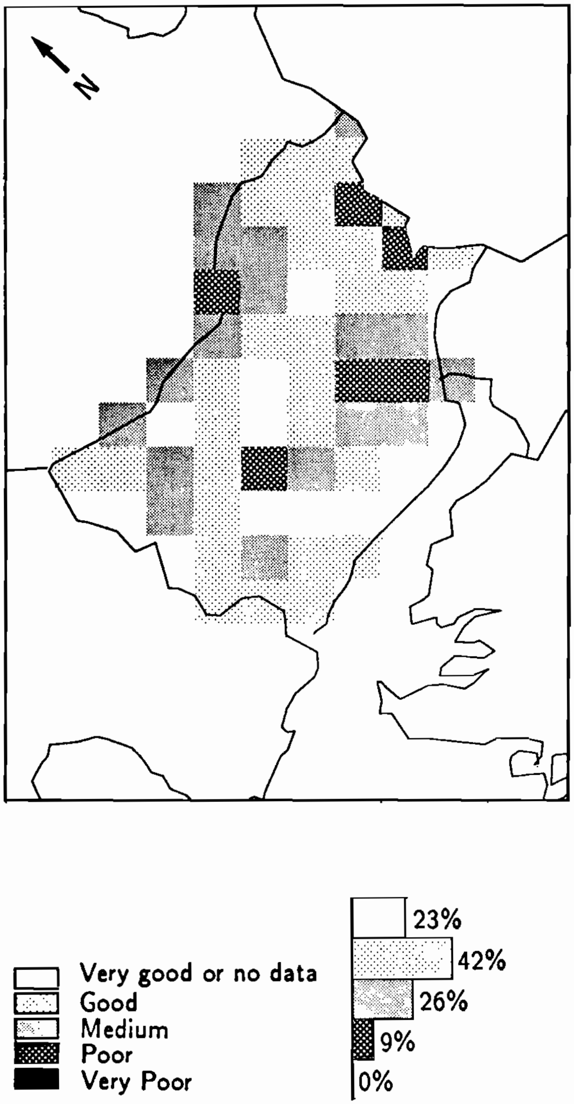

Figure 3.8. Water quality in Bulgaria.

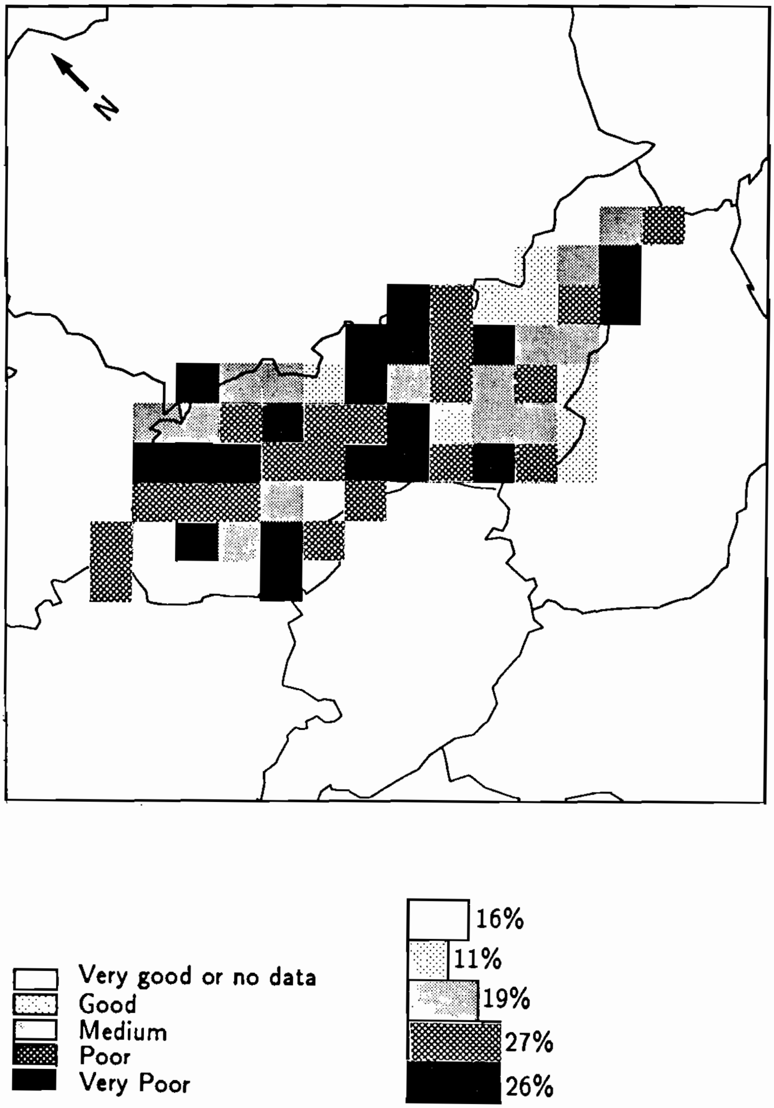

Figure 3.9. Water quality in the CSFR.

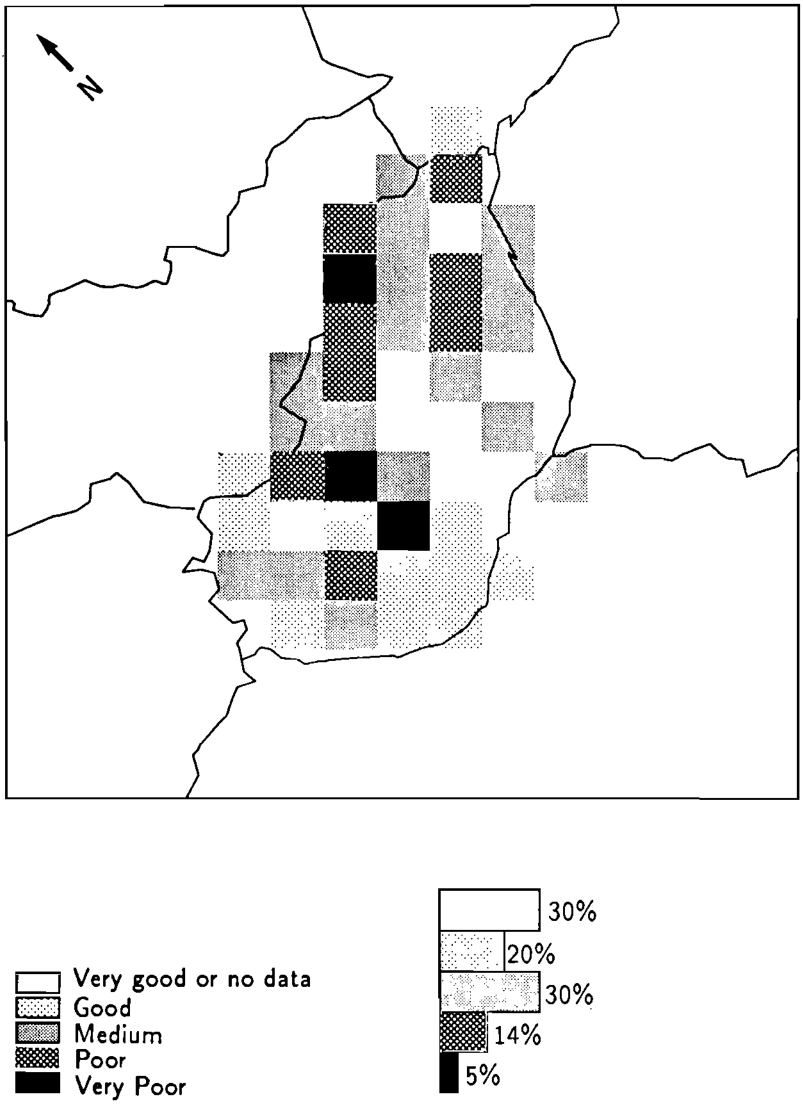

Figure 3.10. Water quality in Hungary.

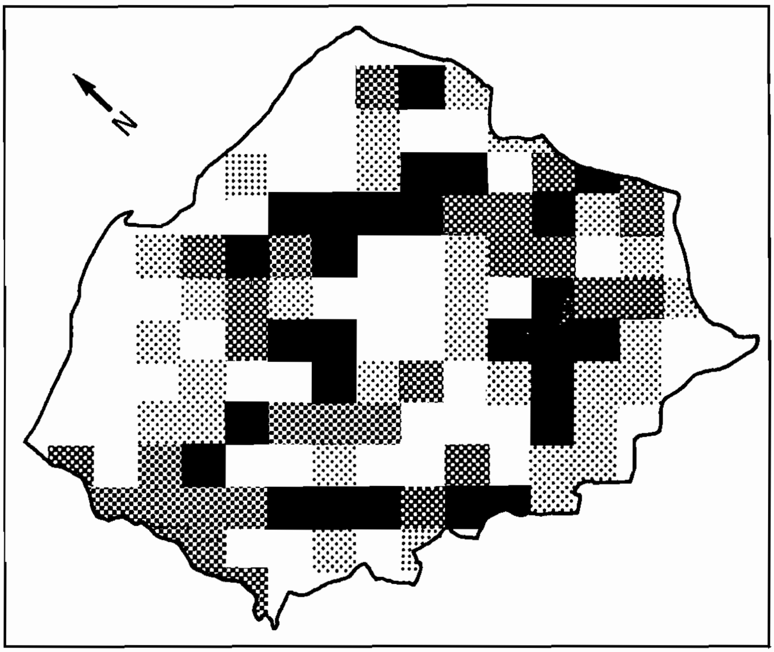

Figure 3.11. Water quality in Poland. Rankings refer to classification of river water quality given in *Basic Monitoring: Report on Water Quality of Rivers Measured in 1990*; Institute of Meteorology and Water Management, 1991. There is no "medium" ranking in this classification system.

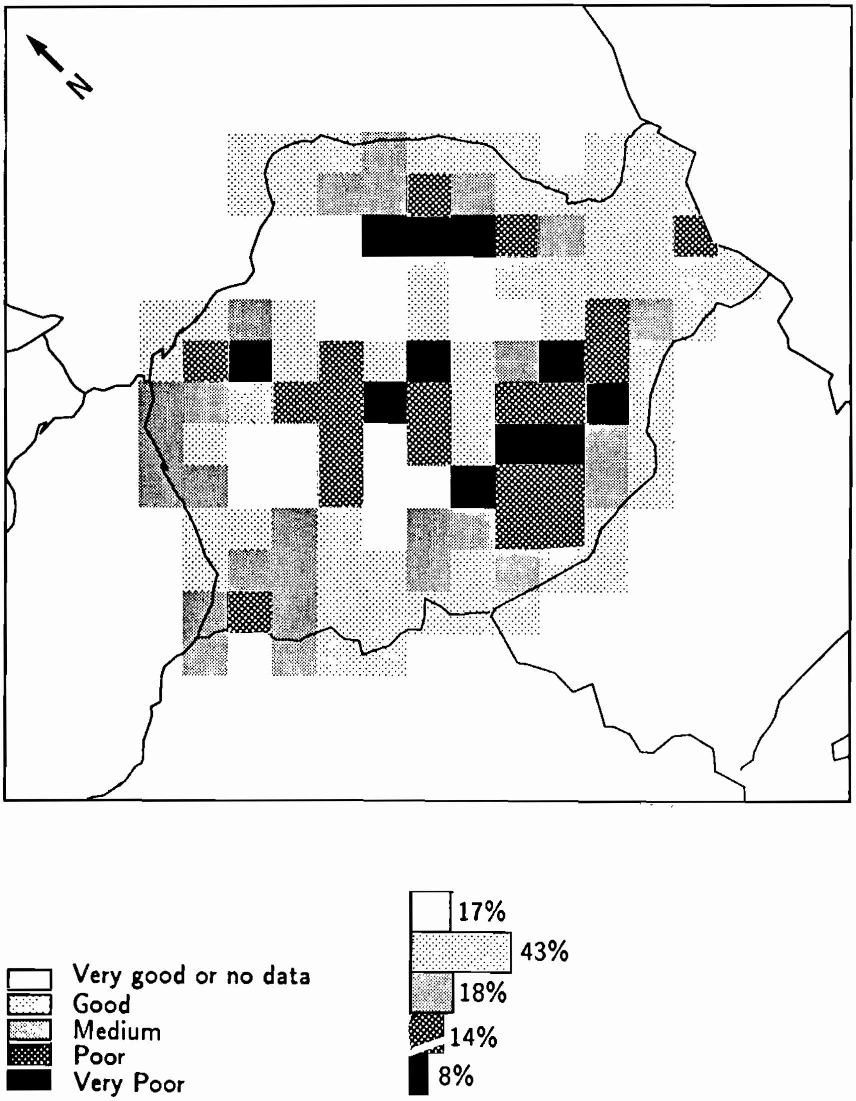

Figure 3.12. Water quality in Romania.

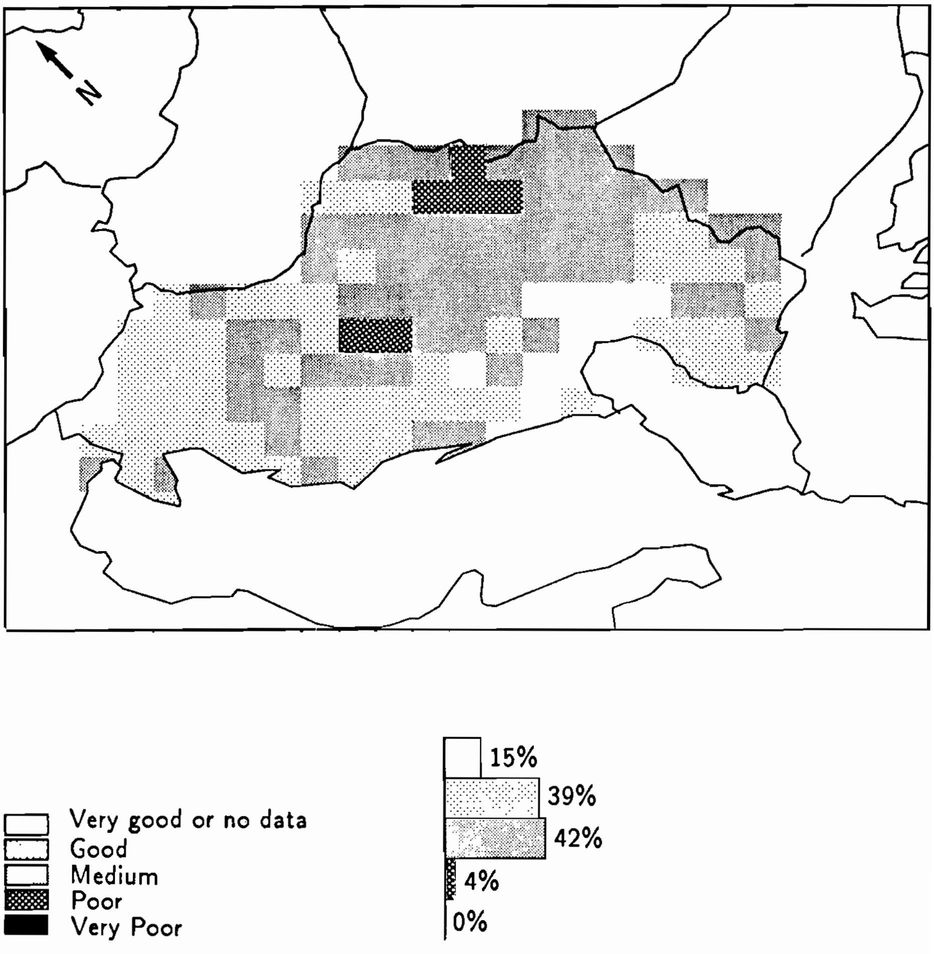

Figure 3.13. Water quality in Yugoslavia. (This map was prepared before mid-1991.)

3.3 Results for the Entire Region

Despite the reasonable degree of consistency between experts of different countries, the subjective nature of these data makes it unwise to combine all five categories into a common map for Central and Eastern Europe. The conclusions from such a map may give the impression that one country has much more severe problems than another. (One expert may examine environmental data and decide that the situation is poor while another may look at the same data and rank the situation as very poor.) Also, some inconsistencies remain among experts in certain border areas, especially where environmental quality is in the very good to medium range.

Taking all this into account, it was decided to present only data from the two worst categories in the regional maps (*Figures 3.14* and *3.15*). One advantage of this approach is that experts from different countries usually agreed that areas had either poor or very poor environmental quality.

These maps provide an overview of the severest environmental problem areas in Central and Eastern Europe, the so-called hot spots. For air quality, 5.8% of the total area of six Central and Eastern European countries was assigned a very poor air quality, and 18.6% of the area was assigned either poor or very poor quality (*Table 3.1*). Results for water quality were close to results for air quality: a very poor quality was assigned to 9.7% of the territory, and 24.1% of the territory had either poor or very poor quality.

3.4 Qualifications and Conclusions

Although *Figures 3.2* to *3.15* present a useful overview, the limitations of these maps should be reiterated. First, because of the necessary but crude spatial resolution of these maps (50 km × 50 km), many local and perhaps important hot spots are not depicted. These would include scattered and relatively isolated pollution sources, such as metallurgical plants located in small towns or rural landfills with hazardous wastes or military arsenals with unsafe waste disposal. Second, the assessment of environmental quality was mostly by subjective ranking based on

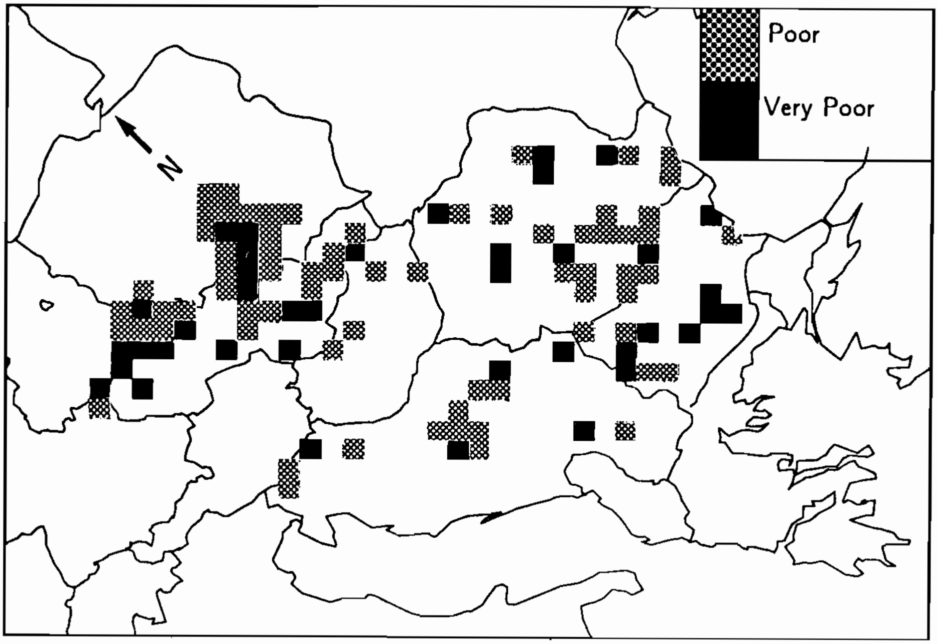

Figure 3.14. Air quality in Eastern Europe.

criteria that differed from country to country. Despite this, there was a fair amount of consistency between experts.

With the above limitations in mind, we note that the hot spots in Central and Eastern Europe (those areas assigned a very poor air or water quality) amount to about 6% to 10% of the total territory of the countries examined. If we include those areas rated with a poor air or water quality, the total territory having severe environmental problems is from 19% to 24%. This is the territory that should be at the heart of a plan for emergency environmental protection in Central and Eastern Europe.

Acknowledgments

The following experts contributed data to the maps: Bulgaria – George Djolov (air quality), Alexander Sadovski (water quality); the CSFR – Jaroslav Stoklasa and Ladislav Miklós (air and water quality); Hungary – László Gajzago (air quality), László Somlyódy (water quality); Poland – Karol Budziński (air

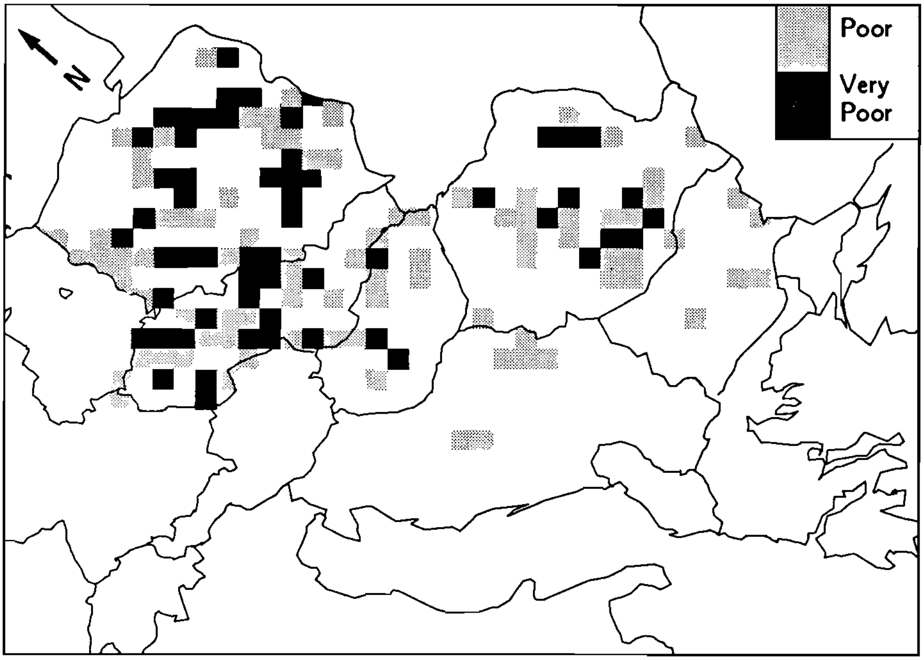

Figure 3.15. Water quality in Eastern Europe.

quality); Romania – Teodor Ognean and Angheluţă Vădineanu (air and water quality); and Yugoslavia – Zorka Vukmirović (air quality), Velimir Pravdić (water quality). The map for water quality in Poland was constructed by the editor, based on data provided by the Ministry of Environmental Protection, Natural Resources, and Forestry, Warsaw, and the Institute of Meteorology and Water Management, Wroclaw. The mapping was performed with the IIASA *GEOMAN* graphics program developed by Peter Raffelsberger. The technical assistance of Wolfgang Schöpp, Edward Tafel, and Barbara Lübkert-Alcamo in producing the maps is gratefully acknowledged.

Chapter 4

International Priorities for Sustaining Natural Resources in Eastern Europe

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International Union for the Conservation of Nature
Cambridge, UK

This chapter provides an overview of the status of biodiversity conservation in the countries of Central and Eastern Europe as a first stage in identifying existing national and international efforts directed at maintaining diversity.

The first part looks at the region country by country. National efforts are described in three of these countries (an indication of where most of the West's environmental assistance is directed), and a detailed appraisal of the situation in Hungary is given. This combined, overview-focus approach may be useful in identifying the overlap of regional priorities with national priorities, thus avoiding duplication in assistance packages.

4.1 Biodiversity Reviews

Bulgaria

Bulgaria straddles the boundary between Continental and Mediterranean climates. It can be divided into five regions: the fertile Danube plain in the north, running along the border with Romania; the Stara Planina Mountains, a 600-kilometer long mountain chain running east to west; the central plain and valleys of the Maritsa River immediately south of the Stara Planina; the mountains of the Rila Planina, Pirin Planina, and Rodopi Planina in the southwest; and the relatively flat areas along the Black Sea coast. Lowlands (0 to 200 meters) cover 31% of the total surface area of the country; hills (200 to 600 meters) cover 41%; highlands (600 to 1,600 meters) cover 25%; and mountains (over 1,600 meters) cover 3%. The climax vegetation is *Quercus* up to 1,000 meters, *Fagus* between 1,000 and 1,500 meters, and coniferous woodland up to 2,200 meters, with some especially well-developed stands of *Pinus peuce* in the Rila, Pirin, and Rodopi mountains.

Under the initiative of the Council for the Protection of the Countryside a number of bills and decrees were published and the country's first national park, Mount Vitosha, was established in 1933. After this date few new protected areas were established until the 1960s. The total number of sites protected has risen from 50 in 1940 to about 130 in 1973 to 3,922 in 1989. In 1989 these areas covered 195,155 hectares or nearly 2% of the country. The Council planned to increase this figure to 3% by the year 2000. Zoogeographically, 77% of reserves belong to the Balkan and the Rila-Rodopi range. An inventory has been made of representative ecosystems covering areas over 1,000 hectares in separate reserves; more than 20 forest formations have been catalogued. In 1982 forests covered 38,590 square kilometers (35% of the land surface). More than 25% of forests are under special protection.

The main wetlands lie along the banks of the Danube River and the coast of the Black Sea. However, many of the marshes and coastal lakes have been drained, largely for agriculture; the remainder are particularly important for migratory bird species. The northeastern part of the Black Sea coast has some remnant steppe areas. The lowlands have largely been converted to agricultural land and some upland areas have been devastated by grazing, mostly by sheep. Tourism, especially skiing, is a potential threat to the remaining less disturbed upland areas. Certain regions (seacoasts and mountains) have been subjected to increases in the number of visitors to protected areas as a result of urbanization, road construction, and easier access to sites. Nature trails are popular and are being constructed in protected areas. Threats arise from the lack of sufficiently severe penalties for misuse or from not adhering to governmental decrees. Cattle grazing is still allowed in some nature reserves, and poaching (hunting and fishing) continues to be prevalent in others, with unknown effects on natural species.

CSFR

Most of the Slovak Republic is mountainous as are the northern and southern boundaries of the Czech Republic. Agricultural land covers 69,000 square kilometers (54% of the land surface): 48,000 square kilometers of this is arable, 8,000 square kilometers is meadow, and 8,000 square kilometers is pasture. Much of the remaining area of the country is covered by forest, with broad-leaved deciduous forest (extensively afforested areas of *Picea* and *Pinus*) at lower altitudes giving way to mixed coniferous and deciduous woodland at higher altitudes and *Pinus* in subalpine zones. The forests, particularly in the northwest, are among the worst affected by air pollution in Europe. In warmer areas, close to the Hungarian border, there are remains of steppe-woodland and steppe-grassland vegetation.

Land is for the most part under state ownership; where private enclaves exist in protected areas, owners are obliged to conform to legal requirements.

On the basis of the document *The Environment in Czechoslovakia* (June 1990) a *Draft Concept of State Ecological Policy* was produced which described future policy directions. This was followed in July 1990 by the document *Ecological Programs and Projects*, which added details to the policy and described specific objectives including the development of national and international parks.

The Czech Ministry of Environment, through its state nature conservation bodies, provides advice on state and republic plans; agricultural, water-management, and energy projects; and all types of physical planning. In response to environmental crises, a national plan – the Eco-Program – is being developed, aimed at integrating ecology and economic activity. A national conservation strategy is also being prepared and contains a species preservation strategy for the Czech Republic.

Total protected area is given as 10,869 square kilometers in the Czech Republic (13.8%) and 8,163 square kilometers in the Slovak Republic (16.7%). The first establishment of protected areas was in 1838 when two forest reserves were created in south Bohemia, followed by additional reserves in 1858 and 1884. An ordinance protecting natural monuments was promulgated in Slovakia in 1900. The first national park was created in the mountainous High Tatras in 1948, and the first protected landscape area (Ceskyraj) was established in 1955. A plan for the development of the protected area network to the year 1990 envisages an increase of 490,000 hectares or an addition of 10% to the area.

Newly devised and designated protected landscape areas (PLAs) are intended to be areas for testing sustainable development policies. Some of the best preserved and most valuable PLAs are being transformed into national parks.

A second group of protected areas comprises a large number of sites from several hectares to several hundred hectares (only a few reserves extend over a 1,000 hectares). The most important small-size areas are the state nature reserves which preserve a broad range of both original (natural) and modified (seminatural) ecosystems.

The varied geological substratum and relief endows the country with a rich biological diversity. Practically all Central European ecosystems occur in the territory of the CSFR, except those typical of the coast and the highest altitudes.

This biological diversity, however, is seriously threatened. Species have disappeared mainly because of habitat degradation and destruction. The threat to biological diversity not only concerns individual species (and their populations) but involves whole biological communities and ecosystems (biotopes). Among the most threatened, and actually disappearing, are wetlands and meadows. Global and local pollutions reduce biological diversity even in those habitats without direct human impact (streams, ponds, and their shores; coppices and edges of larger woodlands; roadsides and ditches; and other areas).

Laws exist to protect rare and threatened species, and the establishment of protected areas has been strongly motivated by the need for preservation of biological diversity. The occurrence of critically threatened species has been recognized as one of the main criteria for the development of a representative protected areas network. Also some new, nontraditional, active methods of species protection are being developed and applied: habitat management, transfers, ex-situ cultivation, and captive breeding. Research and monitoring have been oriented toward the protection and rational use of biological and genetic diversity over the last few years.

From the environmental conservation point of view, the most important vegetation zone is forest. Forest area is adequate, but its distribution is not widespread enough, and currently it is exposed to strong destructive impacts such as air pollution and excessively high numbers of game animals. Approximately 80% of the woodland in the CSFR has been converted to coniferous monocultures (mainly spruce and pine) of low ecological value.

The most serious forest deterioration and destruction is caused by air pollution, so-called acid rain. In the Czech Republic, some 420,000 hectares of woodland (mainly in north Bohemia) have been affected by industrial emissions; in the Slovak Republic, almost 30,000 hectares have been devastated, two-thirds of this in the heavily polluted area around Ziar and Hronom.

The restoration of woodland destroyed by acid rain is the most difficult and important task for contemporary forest management in the CSFR. Timber production is no longer a priority, the maintenance of environmental balance and stability having become the most important goals. In addition, there is a growing interest in the nonproductive functions of woodlands, such as recreation. About one-third of the total forest cover has been declared as "forests of special distinction" with emphasis on environmental and social benefits.

Former GDR

Although the socialist government of former East Germany had not designated any national parks, it had an excellent system of protected areas covering 19% of the country's surface (2.07 million hectares) classified as 766 natural protected areas, 404 landscape protected areas, and 9,500 natural monuments. The first protected site in eastern Germany was established in 1852 at Teufelsmauer (Devil's Wall) near Quedlinburg, followed in 1886 by the bird sanctuary at Seebach near Mühlhausen. Unfortunately the area also has a system of 5,000 waste dumps largely unregistered and uncontrolled as well as Europe's largest nuclear-waste dump near one of the West Germany's power plants, an example of negative environmental cooperation or export. Threats to the environment are largely from industrial and agricultural development.

Before unification, plans were being made by the government to put aside 10% of the national area for nature protection, including lands previously used by the army and former leadership. The first five national parks and six additional biosphere reserves were designated by the Volkskammer (the GDR parliament) on 12 September 1990. It is now up to the new Bundesländer to plan and designate these areas. The new biosphere reserves are subject to the agreement of UNESCO's Man and the Biosphere Committee. It is hoped that these measures will preserve ecologically intact and unique habitats, as well as support programs for the protection of endangered plant and animal species. Problems may arise over who actually owns the land, as claims are already being made for property in former East German areas.

The former East Germany consists mostly of agricultural lands. In the north, oak (*Quercus*), beech (*Fagus*), and pine (*Pinus*) make up the main natural woodland cover, but much of this has been replaced by coniferous plantations. In the south there is a vertical zonation of oak and hornbeam (*Carpinus*) forest which gives way to montane beech forests and, above 500 meters, forests of beech, fir, and spruce. Forests cover 29,500 square kilometers (27% of the country).

Hungary

The majority of Hungarian territory is lowland, dissected by the Danube and Tisza rivers. The low mountains in the north reach a maximum altitude of 1,015 meters. Protected areas include examples of the four main natural vegetation types: mountain bog or peat; mountain meadows containing important alpine flora; steppe; and broad-leaved and coniferous woodland. Other protected habitats include lakes (Lake Balaton is the largest lake in Central Europe and an important bird migration area), volcanic mountains, and extensive cave systems. The climax vegetation of the Great Hungarian Plain was steppe-woodland, dominated by *Quercus*, most of which was removed during the sixteenth and seventeenth centuries, and replaced by steppe-grassland or puszta (an alkaline and very saline grassland rich in annuals).

Hungary is densely populated, with an agriculturally dominated economy. Forests still cover 17% of the land (increased from 12.4% in 1945), while meadows cover 5.4% and arable and grazing land covers 67.7%.

The first protected area was the Forest of Debrecen, which was designated in 1939. By 1970 the total protected areas system covered only 15,000 hectares; in less than 10 years, by the early 1980s, it was increased to over 400,000 hectares. By the end of 1987, protected areas covered 550,000 hectares, approximately 5.9% of the country.

In Hungary, protected areas are designated at the national or local level, according to their degree of importance. Those of national (and in some cases international) importance are national parks, protected landscape areas, and nature conservation areas. In addition, caves form a special category; all caves are under national protection. Sites of local importance are county nature protection areas and natural monuments.

The puszta steppes are threatened by intensification of agriculture, rice crop production, and, most recently, land-use and ownership changes. Other major threats and problems include soil erosion, threats of floods, and the proposed Gabčikovo/Nagymaros Danube River Barrage System (GNRBS), which threatens to disrupt water levels along the Danube; work on this project has been halted on the Hungarian side since May 1989. The Soviet army has been accused of using territory within national parks for firing ranges and ammunition dumps.

Only a handful of threatened species receive active conservation attention. At least 40 plant species (1.3% of the taxa surveyed) have died out since the middle of the last century. Nearly all of these were relics of wetland habitats, of which only one or two now remain in the country.

Animal populations suffering the worst losses have been those inhabiting grassy steppes, saline biotopes, meadows, riverine forests, and ancient forests. However, some species, such as the lynx, have been re-established.

Most of the country's protected areas are covered by forest, much of which suffers from air pollution which primarily affects sessile oaks and for which there is as yet no remedy.

Poland

Polish conservationists were historically among the first to develop advanced conservation concepts including the development of landscape protection for the High Tatras in 1876, only four years after Yellowstone National Park was created.

A red data book program was begun in 1981. Ecological data are provided for each species, together with maps of threats to these species and conservation proposals. Protected areas covered 7.9% of the country's surface in 1986 and are to increase to 27.9% by the year 2000. Five northeastern provinces (voivodships) have signed agreements to create an ecologically protected region, with assistance from the US Environmental Protection Agency.

The landscape is dominated by the northern European plain which covers the majority of the country (only 9% of the land lies over 300 meters) bordered to the north by the Baltic Sea and to the south by the Carpathian Mountains. There are lake districts in the northwest and the northeast (over 1,000 lakes covering 2% of the country), and some of Europe's most extensive lowland peatbogs (1.5 million hectares) in the east of the country. The landscape is principally agricultural but has 30% forest cover (with natural elements containing *Quercus*, *Tilia*, and *Carpinus*; *Picea* and *Pinus* are found in the mountains).

Legal provisions for the conservation of nature and landscape have a long tradition in Poland. Specific nature protection and hunting legislation dates back to the reign of the Piast and Jagiellonian dynasties (fourteenth century). However, none of five national parks created in Poland before 1936 were legally recognized.

In 1988 the total area protected in national parks and nature reserves amounted to 252,791 hectares (0.8% of the surface area of the country), while the total area of all types of protected territory, including protected landscapes, reached about 5,724,694 hectares (18.3% of the country). According to the development plan for nature conservation, the total area of national parks will amount to 230,000 hectares by 1990 (141,414 hectares in 1989) with the addition of five new parks and the extension of a few existing ones, while nature reserves should increase by 86,000 hectares, giving a total area of 198,888 hectares (111,177 hectares in 1989). The total protected area is projected to be 8,734,500 hectares or 28% of the surface area of the country. In the 1980s only two national parks were created (Gorce and Wigry), while one park was extended by the addition of a buffer zone. Only four had legally satisfied their area management plans, three parks were awaiting extension, and six others were in the process of ratification. As of January 1989, there were 15 national parks (141,414 hectares), 970 nature reserves (111,377 hectares), 54 landscape parks (1,992,753 hectares), and 159 protected landscape areas (3,479,150 hectares).

The major threats to national parks are a combination of uncontrolled tourism, air and water pollution, and unsuitable forms of economic development. A survey in 1983 suggested that two-thirds of the surface area of Poland's forests is in a disastrous state and industrial pollution has directly damaged 654,000 hectares of woodland. The National Spatial Management Plan (1986) identified 27 regions (11% of the surface area of the country) as ecologically damaged, nine national parks and six landscape parks as severely threatened, and 23 health resorts as threatened. In 1982 the Academy of Sciences published a nine-volume report, *State of the Environment*, disclosing ecologically threatened areas. Four areas were declared "ecological disaster" areas in 1985 with a further 23 areas of "high ecological risk." Also in 1982, the Polish Forest Society elaborated a report on the "State of Forests and Their Management in Poland." This document discloses that from 1954 to 1980 more than 610 million cubic meters of wood, about 115 million over the projected limit, were cut down. Each year's wood production averaged 123% of the limit. A significant share in this production came from national parks and reserves. Because of the number of tourists (currently 9 million a year) there are proposals for national parks to be zoned to provide areas for recreation, communications, and other uses.

The unsustainable exploitation of natural resources in Poland has caused a dramatic change in the composition of native living natural resources, particularly forests, while seminatural habitats are badly degraded by the excessive pollution of the atmosphere, soils, and water by compounds of sulfur, nitrogen, fluorine, and heavy metals. Coniferous forests, which predominate in central and northern Poland, are highly sensitive to, and are at risk from, air pollution. The extent of damage is constantly rising. Some so-called hidden damage is also occurring, which will become apparent only after some time. The phenomenon of forest death, which is assuming the proportions of an ecological catastrophe, is evident in several areas, notably in the Sudeten Mountains, Silesian Uplands, and the Cracow region.

Fauna in Poland has also suffered losses. Of the 625 or so vertebrate species that once existed in Poland, 15 have become extinct during the last 100 years. Several dozen species have experienced population declines and range contractions, especially those inhabiting ancient forests, marshes, inland waterways, and coastal zones.

Romania

Until 1989 there was just one designated national park (Retezat). In 1990, 11 national parks were created. An additional national park, Dracea, has been proposed. Together these areas cover 664,057 hectares (2.79% of the country), which include buffer and pre-park zones and also the proposed extensions of Retezat National Park.

The 355 science reserves (including areas within Retezat National Park) total an area of 197,900 hectares. Seventeen reserves are larger than 2,000 hectares, 31 are between 300 and 1,000 hectares, the remaining 305 are smaller than 300 hectares. The Danube Delta Biosphere Reserve, set up in August 1990, must now go to a parliamentary vote. If approved, it will be the fourth biosphere reserve in the country; the previous three were established in 1979.

The country comprises lowlands lying below 200 meters (33%), hills and highlands between 200 meters and 300 meters (36%), and mountains averaging 800 meters (31%). Forests cover between 20% and 27%. There are three main vegetation zones: steppe in the southeast (largely under agriculture), forest-steppe in the center of the country, and montane forests in the Carpathians.

Proposals for the protection of the landscape and natural monuments date back to 1907. In the 1980s, the Commission for Protection of Natural Monuments, in collaboration with the General State Forest Management Inspectorate, developed a national park system consisting of at least 12 parks. The study dealt with establishment criteria, organization and management, and preparatory studies covering four new national parks.

In the early 1980s between 300 and 310 nature reserves covered 0.5% of the country. By 1986 there were 420 reserves and one national park together covering 222,545 hectares.

The natural environment is currently threatened by a combination of factors such as industrial pollution, intensification of agriculture, and uncontrolled tourism. For example, the Rosca-Letea Biosphere Reserve, until recently threatened by agricultural development, is still affected by upstream pollution sources.

Yugoslavia

Geographically in the center of the Balkan Peninsula, Yugoslavia has a great diversity of habitats, being under the influence of Mediterranean alpine and lowland Pannonian climates. Deciduous oakwoods cover the karstlands of the far north and the far south between 200 and 700 meters; oaks (*Quercus*) dominate at these altitudes, but are replaced by beech (*Fagus*) at higher altitudes. Many of the forests are ancient and relatively undisturbed. The central mountains are dominated by coniferous forest, and lower level riverine forests consist of alder (*Alnus*), willow (*Salix*), and ash (*Fraxinus*). The higher mountain massifs are well represented by relatively undisturbed alpine communities with many endemic plants. Coastal maquis is still widespread, with some patchy stands along the Croatian coast. The northern Pannonian Plain is mostly agricultural, but with some relics of steppe flora on saline soils.

A relatively low population density has ensured the survival of a number of important ecosystems, notably forest and alpine systems. In contrast, most of the larger wetland sites have been drained and put under cultivation or pasture since the end of World War II. In several of the wetlands that survive, habitats for breeding waterfowl are seriously degraded or polluted.

The first major inventory of protected areas (Inventory of Natural Regions and Natural Monuments), undertaken in 1976, estimated that such areas covered 2.2% of the country. This figure had risen considerably by the time a second inventory was undertaken in 1987. The number of protected natural regions and monuments had increased from 1,008 in 1976 to 1,313 in 1987. The number of designated national parks had risen from 16 to 22 by 1987, with a total area of 524,784 hectares.

Some problems affecting protected areas include competition with tourism and other economic development and water and air pollution. Many park authorities have insufficient funds and have to rely on financial assistance from tourism, forestry, sporting, and recreational activities. Sites which are near industrial complexes have also suffered from a lack of concern for environmental issues following rapid industrial expansion in the early 1950s.

4.2 National Initiatives for Nature Conservation

CSFR

The CSFR is one of the few countries in the region implementing a long-term program to establish a protected areas system. The main objectives and components of the program are selection of new sites for special protection; reviews of existing sites; management of protected areas according to specific category, features, values, functions, and development of each; use of protected areas for research monitoring, natural resource conservation, biological diversity preservation, ecological landscape maintenance, education and training, and tourism and recreation.

The basic approach is flexible. The main concepts are priority of large protected areas, especially protected landscape areas, as pilot sites for the implementation of ecologically sound, sustainable development of a cultural landscape; identification of sites that may lose their ecological value thus requiring special protection; and allowance in selection criteria for protected areas to cover not only natural but also modified (seminatural) ecosystems.

In the early 1980s, an attempt was made to promote the federal Eco-Program encompassing the goals and objectives of the World Conservation Strategy. At present, the Eco-Program is being developed chiefly at the district level. Some Czech districts (especially Rakovnik and Kolin in middle Bohemia) are particularly active in this regard.

In pursuing sustainable development, it is essential to ensure the preservation and creative conservation of ecologically sound components of the environment. Accordingly, during 1988 important landscape elements were identified throughout the CSFR. This task, titled "Balance Sheet of Important Landscape Elements," was ordered by the CSFR government and accomplished jointly by the State Nature Conservancy and TERPLAN – the Czech Institute for Physical (Territorial) Planning.

Following the previous accounts of the environmental situation and trends in the CSFR, priorities for action can be described as ecological optimization of land use. There is a need to stop the conversion of arable land into urban and other nonarable areas, to fight the dangers of soil fertility loss, and to control eutrophication, pollution, and contamination caused by industrialized agriculture. Soil erosion must be reduced. Greater biological diversity can be used to help landscape maintenance. This will mean preservation, reintroduction, rehabilitation, and reconstruction of populations of wild plants and animals and their habitats. The scenic values of the countryside, especially small wetlands and streams, and other natural and seminatural ecosystems, also need to be maintained and enhanced. The role of physical (territorial) planning has to be strengthened, and the plans elaborated and approved must be fully respected and followed in land-use practice.

Hungary

In Hungary the maintenance of favorable natural conditions and the reconstruction of deteriorated biotopes are of vital importance for the success of nature conservation. Both need active and continuous intervention from nature protection agencies. A first step in the reconstruction of damaged areas is for ownership to be taken over by an environmental protection agency. A program exists to acquire the most valuable or the most endangered biotopes as far as Hungary's financial situation will allow.

Future projects and on-going research programs include:

- A population survey of endangered plant and animal species.
- Basic research on the protection and reconstruction of natural ecosystems.
- Research programs for management of protected areas.
- Artificial propagation and reintroduction methods for protected and endangered plant and animal species.
- Development and expansion of extensive management methods for area conservation.

The basis of all work of the agency is the conservation of species and their habitats. Thus, the agency's main duty is to concentrate on the reconstruction of deteriorated biotopes.

The survey of national natural resources must be sped up, and protection programs that take advantage of international cooperation must be designed. The most valuable and most endangered biotopes must be conserved. Provision must be made for their maintenance and for the restoration of existing degraded biotopes. The efficiency of protection must be raised and the functions of protected areas widened, especially in the interests of raising public awareness. Existing facilities and teaching trails are of great importance in this respect, and more must be provided in the future.

Poland

The implementation of plans for the protection of air and surface and ground waters against pollution is an essential prerequisite for planning the protection of living natural resources. Under current conditions in Poland, the main priority of environmental protection is to implement sustainable development, whereby all types of protection (national parks, nature reserves, landscape parks, and protected landscape areas) are treated as a linked system. This is consistent with the main aims of the nature-protection strategy based on the World Conservation Strategy:

- The maintenance of basic ecological processes and systems that are the mainstay of life.
- The preservation of genetic diversity.
- Ensuring the continued use of species and ecosystems that satisfy social needs and human subsistence.

A problem of importance in Poland is the accelerating threat to the forests, which has taken on the form of an ecological disaster in the southwestern part of the country.

The most important issue facing the protection of the natural environment in Poland is the conservation of living natural resources. The key problem here is to prevent the destruction of coniferous forests by atmospheric pollution and acidic precipitation. Forest degeneration is rapid, but the time needed to restore damaged forest communities is reckoned in decades.

National parks are also endangered, particularly in the mountains of southern Poland. The borders of these parks constitute no tight barriers to the flow of air pollution. The wetland reserves of northern Poland are less threatened by atmospheric pollution, but are nevertheless damaged or destroyed by drainage, water storage, and irrigation schemes.

4.3 International Action

4.3.1 The European Community's PHARE Program

Poland

One example of the European Community's support for nature conservation is its financial underwriting of the Nature Conservation Foundation for the Great Mazurian Lake Region. This support is part of the EC's PHARE Program (Poland-Hungary Assistance to the Restructuring of Economies). The Mazurian Lake System is a unique biome. Located in the north of Poland, the Mazurian Lake System consists of some 2,000 interconnected lakes with a total surface area of about 310 square kilometers. The region is undergoing important industrial, urban, and tourism development. Only 5% of the Mazurian Lake System is unpolluted, but 38% is extremely polluted. Municipal and industrial wastes are stored in a completely uncontrolled way. Agriculture is intensifying, which is leading to increased use of fertilizers and pesticides. A coordinated action plan is needed to combine economic development and environmental protection in the Mazurian Lake region and also to limit the pollution of the Baltic Sea, which collects most of its water from the Mazurian region.

Hungary

As part of the PHARE Program, the EC is also supporting the establishment of Fertö Lake National Park. Fertö Lake (Neusiedler See) is the third biggest lake in Central Europe. It is a typical flatland saline lake, with unique fauna and flora. It is also situated in an area that is rich in historical monuments. Most of the lake's surface area is located in Austria, with about 30% in Hungary. The lake is under protection in both countries, and the governments agreed in 1988 to establish a national park in this area. A bilateral commission of experts has been set up to implement this agreement. It is expected that the park will be established soon.

The EC is also funding a study of several areas with unique wetland and grassland ecological systems that are located in the national parks of Kiskunsaq and Hortobagy. The ecological quality of these areas has been deteriorating over the last 20 to 50 years because of flood protection and drainage measures that have altered the hydrological characteristics of the areas, inappropriate agricultural land use, and several dry periods during the last 10 years. Corrective action will have to be taken in a long-term program that still needs to be defined by a feasibility study.

4.3.2 Other international programs

There are several bilateral, western-aided nature conservation programs in Eastern Europe. One example is a program under which Switzerland provides assistance to nongovernmental organizations concerned with nature conservation in Bulgaria. In another case, the United Kingdom is helping the CSFR to set up a liaison office on nongovernmental nature conservation affairs. The Worldwide Fund for Nature (WWF) also has an active program in the CSFR, Hungary, and elsewhere. In Hungary the WWF has provided support for the Hungarian Ornithological Society, has helped to conduct a species inventory, has gained legal protection for the grass steppes of the Hungarian plains, and has underwritten efforts to protect and restore floodplain habitats.

4.4 Focusing on Hungary

The main goal of conservation efforts in Hungary is conserving biodiversity. This includes habitat and species protection in the form of designated "protected areas." Both areas of interest (habitats and species) will be affected by the form of decentralization of authority and the question of property rights of the protected areas and how these might affect the government's course of action.

Protected areas are designated at the national or local level according to degree of importance. Those of national (and in some cases international) importance are national parks, protected landscape areas, and nature conservation areas; caves form a special category of national significance. The sites protected at the local level are the county nature protection areas and the natural monuments. The total area under protection at the national level is 518,000 hectares in 155 sites and a further

36,000 hectares spread across 791 sites at the local level; this amounts to 5.9% of the country.

The economic and scientific importance of the great majority of the fauna and flora of the country has yet to be assessed. At present there are programs for the protection of just a few species whose environmental importance and conservation requirements have been worked out. These programs protect the great bustard, the white-headed duck, a number of raptor species (Saker falcon and imperial eagle), and the eagle owl, as well as the beaver for which international assistance has been obtained.

The country's involvement in international conservation conventions has expanded in recent years with adherence to the Berne and Bonn Conventions. Of the other major conventions of which Hungary is a member, the most relevant to conservation are the World Heritage and the Wetlands of International Importance (Ramsar Convention). With regard to the former, one natural site was put forward for listing under the convention but was subsequently withdrawn (Hortobagy National Park). With regard to Ramsar, eight sites were listed at the time of accession to the convention in 1979 and a further five were added in 1989, including two sites (Lake Tata and Lake Balaton). Five sites listed as biosphere reserves are also part of UNESCO's scientific program, Man and the Biosphere. One of these, Fertö Lake, is considered a "wetland of international importance"; there are plans to create on this site an international park with Austria. This project has received a PHARE Program grant of ECU1.4 million.

The priority initiatives in the field of conservation include research on the protection and restoration of natural ecosystems and research on the management of protected areas. With regard to protected areas, key actions are expansion of the system of protected areas to ensure adequate coverage of all the major sites of biodiversity and proper management of these sites. The management efficiency of site protection is a major problem to be tackled, and the functions of protected areas need to be rigorously reviewed.

The basis of all conservation work on different species is the conservation of their habitats. Thus, the main task is to concentrate on the reconstruction of deteriorated biotopes which, in order of importance, are grasslands (in particular, the unique steppe grasslands of the puszta plains and the flood meadows of the river valleys in the northeast of the country), forests (in particular, the riverine forests along the Danube and the Tisza), and wetlands.

Under the former system of central planning and authority, those areas which were not included specifically in the planning system and allocated for a specific use were forgotten and, in the absence of private ownership of land, remained largely undisturbed (they of course continued to be affected by such processes as acid rain, water reserve changes due to river regulation, and general pollution). The former regime did manage to create an extensive system of protected areas and did manage to protect a range of key sites of biodiversity. Changes in land ownership may affect land-use planning and allow undesirable changes in the use of areas currently under some form of protection.

Another factor which perhaps explains Hungary's enthusiasm in applying international conventions is that many conservation issues are issues of international responsibility. For example, the country lies on an important bird-migration route and is on the edge of many species ranges that are typically southern and eastern in distribution (for example, the Orsini viper and several raptors).

With regard to nature-conservation laws, the greatest drawbacks are the lack of proper enforcement and abuse of the regulations. In general, there is a great need for raising public awareness of the value of species and habitat protection.

Breakup of the agricultural cooperatives and state forestry companies has meant that the population in many rural areas has greatly decreased; moreover, there are too few people to farm privatized land. On the other hand, unemployment in the industrial sectors may result in a drift back to the land, creating new opportunities and new problems. There is discussion in some parts of the country that areas previously under protection might acquire a role in recreation and tourism.

It would appear that those areas that remain seminatural and under some form of protection have gained this status because they are unsuitable for agricultural or other *productive* use. This was certainly the case in the southeast of the country where the predominantly agricultural landscape is interrupted in a few places by protected remnants of the puszta grasslands. At the local level of decision making, the degree of habitat protection depends very much on the views of local officials. Certain regulations are adhered to, but the overall approach is largely up to the individual. In other sites (Hortobagy and the protected areas north of Lake Balaton), protective status was due to military use (in the case of Hortobagy, the presence of a bombing range; in the case of the Balaton sites, SS-20 missile bases and training areas). In other sites (Fertö Lake) the protected status and good condition of habitats is due to their location on international borders or is a by-product of other processes. An example of the latter is the Kis-Balaton wetland, where the wetland was artificially restored to purify the waters entering Lake Balaton.

In the case of national parks, forest areas in particular, priority is given to forest activities over nature conservation. This is very obvious in the case of Bukk National Park and other forested national parks, including those of international importance (such as Aggtelek National Park, which is a designated biosphere reserve). The de facto order of priority of activities in national parks and protected areas is forestry, tourism, and nature conservation. In the case of Bukk National Park, only 50 hectares out of 36,700 hectares are considered to be natural habitat; all of the park is open to forest operations. Clear felling is restricted to stands of 100 hectares, but these are adjacent to each other and thus amount to clear-cutting on a large scale.

Within protected forest areas, populations of game animals were deliberately increased for hunting. The legislation creating protected areas does not specifically exclude the continuation of previous activities, nor does it control commercial grazing, hunting, or logging. Large parts of the protected forest areas have lost their natural cover, with turkey oak, beech, and common oak being replaced by pine (by eucalyptus in the lowlands), to the extent that 50% of all tree cover in Hungary consists of non-native species. This is apparent in the riverine forest at the Dunakiliti Danube site, where natural species have been almost entirely replaced by commercial poplar plantations.

Because of state forestry policy, the logging industry is currently unable to produce useful products from indigenous trees, hence, these trees must be exported. Yet, the private building industry's demand for softwoods leads to political pressure to replace the native tree cover.

Other protected areas are under pressure from agriculture. For example, in Aggtelek National Park, traditional agricultural practices on the karst grasslands have been replaced by cereal farming. This has occurred despite the fact that the commercial value of the forests is considered to be two to three times that of the value of the forests in the Bukk National Park. This was caused by regulation of the rivers which created different water regimes in the park and the demand for wheat as an export to the Soviet Union. In Hortobagy the use of pesticides and the enormous growth of goose farming are creating problems. In yet other areas (Szarsomlyo, south of Pecs) the uncontrolled and blatant exploitation of a natural resource (limestone) has nearly destroyed a nature conservation area of national importance.

In conclusion, Hungary needs to address the following critical issues:

- Current protected areas and species need to be maintained.
- Local authority to maintain areas should be enhanced.
- Nature conservation organizations and authorities should purchase as much land and property as possible from areas currently owned and protected by the state.
- Legislation that gives priority to forestry and agriculture in protected areas should be revised to give priority to habitat and species protection.
- The greatest priority for nature conservation is the protection of habitat and species despite changes in land use that may result from intensification and privatization of the agriculture sector.

The legislative basis for habitat and species protection is in place at the national level and, indeed, is flexible enough to accommodate international conventions and scientific programs. To become more active in international affairs, Hungary is participating in international conventions such as the Convention on Wetlands of International Importance, the Berne Convention on Habitat Conservation, and the Bonn Convention on Species Conservation.

Hungary has acknowledged its international responsibility for maintaining its key habitats (puszta grasslands and wetlands and the karst cave systems) and key species (great bustard, white-headed duck, raptors, and others). However, it is necessary to:

- Construct a mechanism for the enforcement of legislation at the local, regional, and national levels for habitat protection and restoration of degraded nature.

- Expand the amount of protected area to cover all important sites and the range of biodiversity.
- Regulate the activity in protected areas and in the wider countryside, with priority given to nature conservation over and above that of agriculture, forestry, industry, and tourism.
- Elaborate species management plans and habitat conservation strategies in economic and social policy and support nongovernmental activities in this field by full government backing.

4.5 Priorities for Preserving Biodiversity in Eastern Europe

Priorities for preserving biodiversity in Eastern Europe can be divided into economic, technical, and political categories. The first is dominated by financial debt. The second is dominated by waste production of agriculture and industry and its effects (water and air pollution and negative impacts on human health and biodiversity). The third category is dominated by the place given to environmental matters in government policy and the pressure felt by the government from the public on environmental issues. Other considerations in setting priorities include:

- *International cooperation:* This is due to the geographical position of the countries of Eastern and Central Europe.
- *Distribution of environmental problems:* The distribution of problems in Eastern and Central Europe is uneven; distinct site-specific problems occur in large population centers, at industrial locations, and along major national and international traffic routes. The environmental problems are linked with social and economic issues such as coal mining and the steel industry. Major problems are related to the earlier policy of concentrating on heavy industry, which is both resource and energy intensive.
- *Degree of damage and character:* This is also unevenly distributed among countries. However, there are no areas unaffected.
- *Regulations:* There is widespread abuse of regulations especially in protected areas where they are ignored for short-term gains in industry, agriculture, forestry, and tourism.

Ultimately, biodiversity preservation and nature conservation will depend on:

- Development of mutual trust between government and citizens by public participation in the decision-making process.
- Access of the public to environmental information.
- Creation of a plan by which communities can govern protected areas.
- Creation of a long-range national plan for nature conservation.

Last but not least, nature conservation in Central and Eastern Europe depends on the integration of economic and environmental policies in these countries and the compatibility of the policies with western and international standards.

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Chapter 5

Monitoring Background Atmospheric Pollution in Central and Eastern Europe

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5.1 The Network of Background Monitoring Stations

Bulgaria, Hungary, the former East Germany, Poland, Romania, the former USSR, and the Czech-Slovak Federal Republic cooperated multilaterally in the field of environmental protection from 1976 to 1990. One result of this cooperation was the operation of a joint network of Integrated Background Monitoring (IBMon) stations. The coordinating

Although the USSR has passed into history since this chapter was written, the data reviewed here still provide good insight into the air-pollution situation in rural areas of the region from the Oder to the Urals.

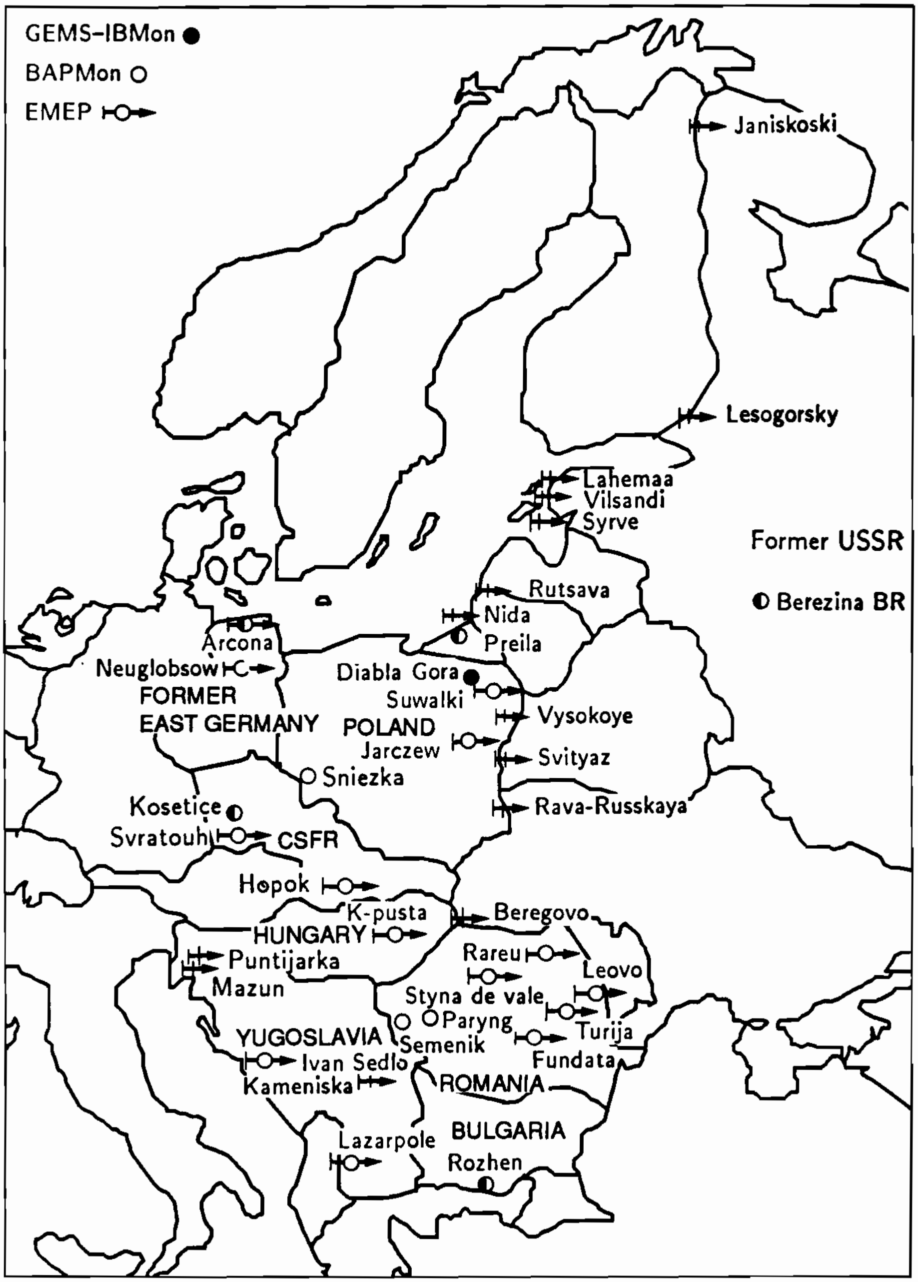

Figure 5.1a. Locations of background monitoring stations in Eastern Europe.

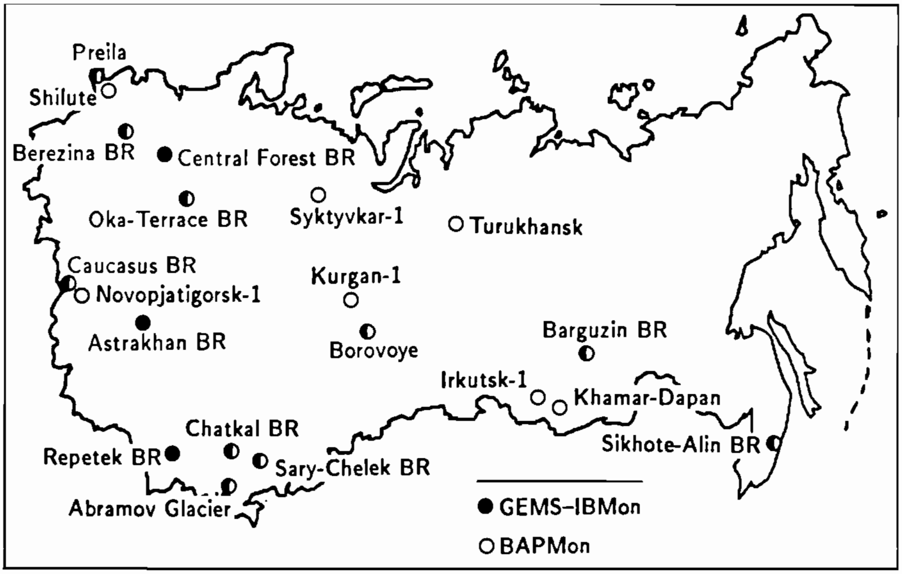

Figure 5.1b. Locations of background monitoring stations in the former USSR.

center of IBMon collects, analyzes, and publishes data from the network. The stations operating under IBMon, BAPMon (Background Air Pollution Monitoring), and EMEP (European Monitoring and Evaluation Program) have been combined in the regional background monitoring system. The station locations are shown in *Figure 5.1.* Some of the stations operate under more than one program.

The IBMon program embraces all the major environmental media: air, water, soil, and biota. The atmospheric component of the IBMon program includes the routine parameters measured by the BAPMon and EMEP programs, plus additional indices of anthropogenic impact: CO_2 and other greenhouse gases, tropospheric ozone, suspended particulate matter, heavy metals, and organic substances (3,4-benzpyrene, organochlorine compounds). More details on the IBMon program can be found in Rovinsky and Wiersma (1987).

Because of the highly variable environmental situation, the low level of pollutants typical for background regions, and the need for high quality data, a strict quality assurance system was established. The recommended methods and procedures for sampling measurement and analysis at background stations are given in Rovinsky (1986), Rovinsky and Wiersma (1987), and WMO (1978).

The data received from the stations are stored in personal computers, with software for data interpretation and graphic presentation. The software allows for data collection, storage, and processing, as well as information services for exchange of data with other data banks and processing of data for use in simulation models. Annual input of information is about 1.5 megabytes, more than 90% of which is atmospheric and precipitation data.

From 1982 to 1986 the coordinating center of IBMon published an annual bulletin. Following creation of the database in 1987, the coordinating center started publication of a new type of annual bulletin that presents an environmental quality assessment based on observational data.

In addition to these publications, the coordinating center also publishes analysis of selected issues concerning background environmental pollution. The coordinating center also regularly publishes scientific papers under the rubric of "Problems of the Background Monitoring of the State of the Environment." This collection embraces all aspects of integrated background monitoring and includes papers presented at international meetings and workshops that are regularly held within the cooperative framework of IBMon.

The coordinating center annually publishes *The Review of the Background State of the Environment in the USSR*, which assesses data received from the national background monitoring system and discusses problems in major economic regions. The scientific papers are regularly published in collections entitled *Monitoring of the Background Pollution of Environmental Media.*

5.1.1 Sources of atmospheric pollution

The majority of priority pollutants are of both anthropogenic and natural origins. At the same time, some substances (DDT, PCB, freons, etc.) are exclusively anthropogenic. Data on anthropogenic sources of some atmospheric pollutants on various scales are given in *Table 5.1.* In terms of mass of emissions, sulfur dioxide leads all other pollutants. More than 50% of this mass is emitted in the North Temperate Zone

Table 5.1. Anthropogenic pollutant emissions into the atmosphere on various spatial scales.

Anthropogenic substances	Global	Northern Hemisphere	Northern Hemisphere temperate zone	Eastern Europe (without USSR)	Former European USSR
Sulfur dioxide[a]	196.0	178.0	>84.0	15.80	8.4
Nitrogen dioxide[a]	20–40.0	–	–	4.30	2.7
Lead[b]	420.0	395.0	370.0	9.20	30.9
Cadmium[b]	9.5	8.0	7.5	0.35	0.3
Arsenic[b]	40.0	32.7	31.0	1.10	2.1
Mercury[b]	6.4	5.8	5.4	0.10	0.1
Copper[b]	80.0	64.0	54.0	3.00	6.5
Zinc[b]	360.0	305.0	260.0	8.30	13.2

[a]MT yr^{-1}.
[b]kt yr^{-1}.
Sources: Anon, 1990; Anderson and Levin, 1987; Cullis and Hirschler, 1980; Ostromoguilsky *et al.*, 1987b, 1969; Pacyna and Münch, 1988; Ryaboshapko, 1983.

(between 30 and 60 degrees northern latitude). Sulfur dioxide emissions decreased by about 25% in Western Europe and 3% in Eastern Europe between 1980 and 1985. The emission of nitrogen oxides is measured less reliably than sulfur dioxide and no appreciable decrease has been observed.

A significant amount of heavy metal emissions is of anthropogenic origin, ranging between 50–60% in the case of copper, zinc, or cadmium and 88–92% for arsenic and lead. For mercury, IBMon (1989) estimates that the percentage is 24%. The uncertainty of these estimates is due to uncertainty in the assessment of natural sources.

Emission sources are related to energy, transport, and industrial activity. For example, significant levels of heavy metals are found in the vicinity of ferrous and nonferrous metallurgy plants. In the USSR, those areas are the central and southern Urals, Donbass, the Kola Peninsula, Central Asia, Kazakhstan, and the Norilsk region.

With respect to the level of DDT in the atmosphere, it is estimated that from the 1940s until 1985 3.5 million tons were used, reaching a maximum of 150,000 to 160,000 tons per year in 1965. By the mid-1970s most of the developed countries had limited or banned DDT use. However, increased use in the Southern Hemisphere compensated for decreased use in the Northern Hemisphere. Ostromoguilsky *et al.* (1987) estimate global DDT use today at 86,000 tons per year. Data for the USSR show a substantial decrease in DDT application since the early 1970s. Use of hexachlorocyclohexane (HCCH) has also decreased from 15,000 tons per year in 1981 to 7,000 tons per year in 1987.

The global source of 3,4-benzpyrene is 4,500 to 5,000 tons per year with a spatial distribution similar to that of sulfur dioxide. Based on the coal, oil, and gas combustion and corresponding emission coefficients, the emissions of 3,4-benzpyrene into the former USSR's atmosphere are calculated to be 985 tons per year.

5.1.2 Assessment of background atmospheric pollution

The information in this section is based on observations at background stations from the beginning of their operation until 1989 inclusive – that is, seven to nine years of data.

Sulfur Dioxide and Nitrogen Oxide

The spatial distribution of SO_2 is heterogeneous and varies latitudinally as well as longitudinally (*Figure 5.2*). Mean seasonal concentrations in summer and winter vary about fourfold latitudinally and three- to sixfold longitudinally. High SO_2 concentrations occur in the western part of the regions under consideration (the former GDR, the CSFR, Hungary, and Poland). High concentrations are also found in the western part of the former European USSR. The spatial pattern of SO_2 results from the distribution of SO_2 emission sources and long-range transport of SO_2 in a prevailing eastward direction.

In addition to spatial variability, a seasonal pattern of SO_2 concentrations is also observed (*Figure 5.2*). SO_2 concentrations are higher during colder months than during the warm season. This effect is clearly seen in the western sector of the region where mean seasonal concentrations usually vary three- to fivefold. During individual months these values may increase tenfold mainly because of increased activity of SO_2 sources during the cold season.

SO_2 concentrations in background regions also undergo daily variations. The daily range can fluctuate up to tenfold and is greater during warm seasons.

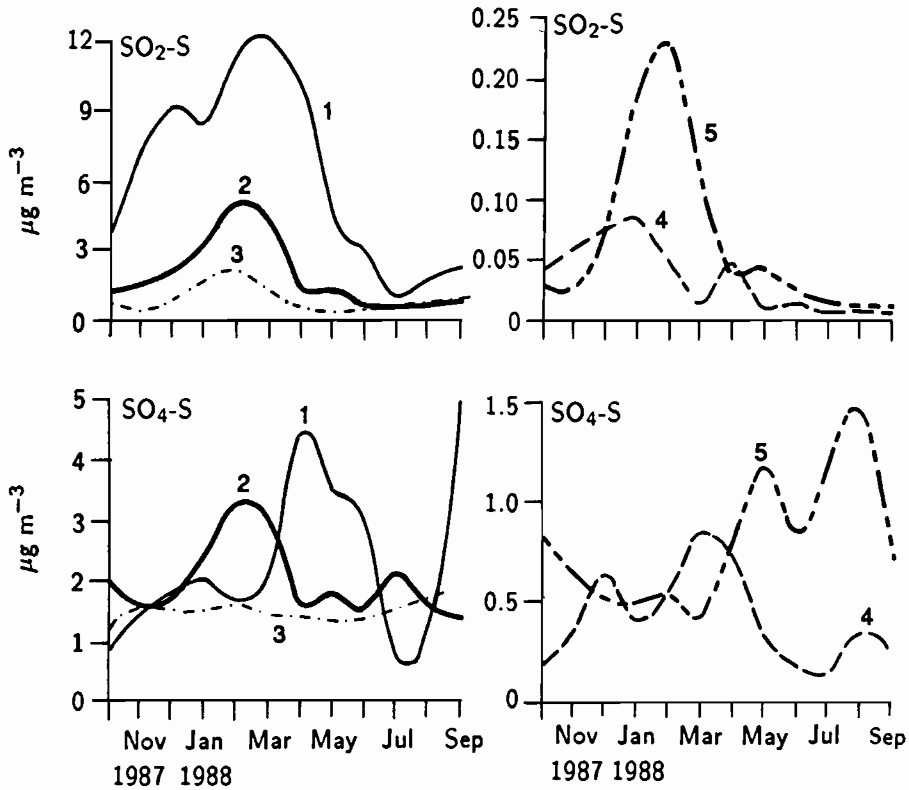

Figure 5.2. Sulfur dioxide (SO_2) and sulfate (SO_4^{2-}) mean monthly concentration in the atmosphere at GEMS–IBMon stations: (1) Eastern Europe (stations 51, 71, 73, 93); (2) former USSR (stations 2, 4, 11, 12, 13); (3) middle Asia and Kazakhstan (stations 6, 7, 8, 9); (4) Siberia (station 5); (5) former USSR high altitude (stations 3, 10).

The analysis of background SO_2 content in the atmosphere (*Figure 5.3*) shows a decreasing trend in the western part of the region after 1985, although this trend is absent in warm seasons. A similar trend, though not as pronounced, is observed for the former European USSR.

The behavior of sulfate aerosols in the atmosphere is much like that of SO_2 in general. However, SO_4^{2-} has smaller spatial and seasonal variability (see *Figure 5.2*). Sulfate concentrations show no distinct

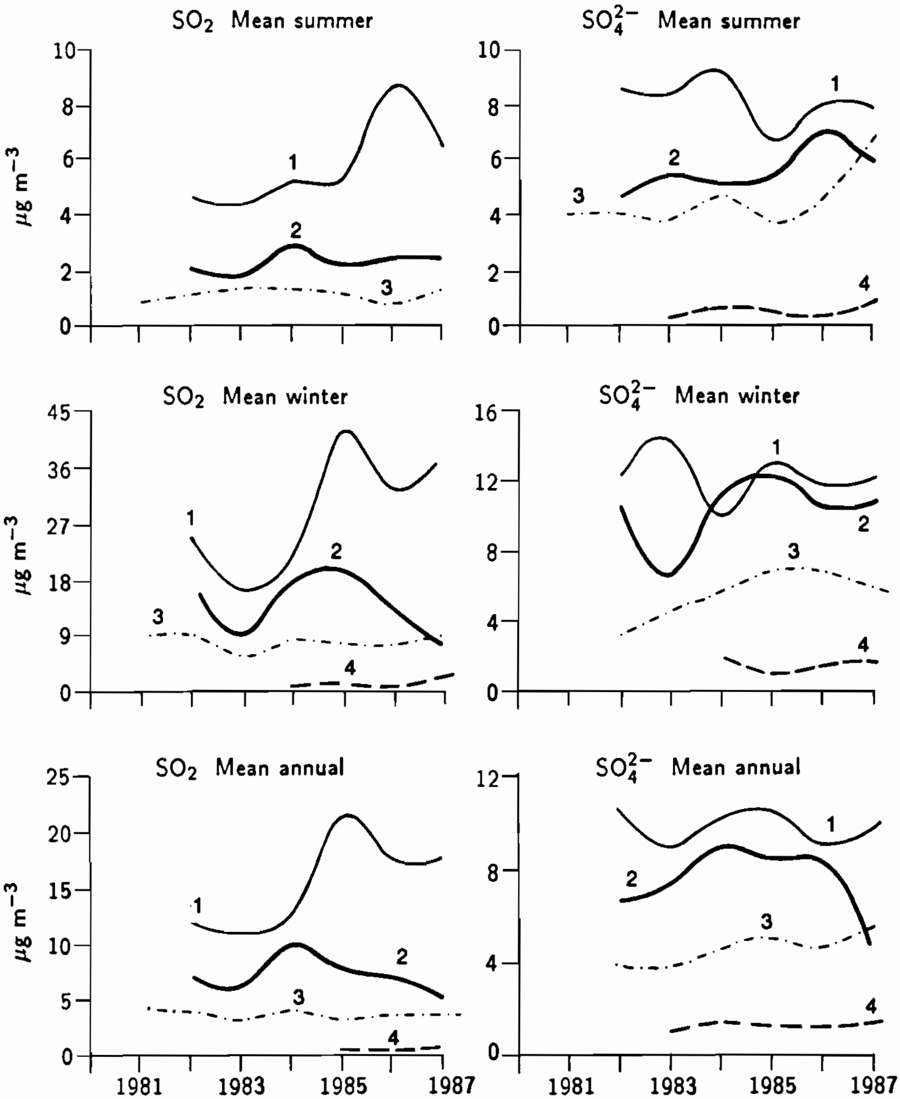

Figure 5.3. Concentration of sulfur dioxide (SO_2) and sulfate (SO_4^{2-}) in the atmosphere in: (1) Eastern Europe, (2) former European USSR, (3) western Soviet Central Asia, and (4) eastern Soviet Central Asia.

multiyear trend, except for a slightly decreasing trend during cold seasons (see *Figure 5.3*).

The spatial distribution of nitrogen oxides agrees in general with that of SO_2. Maximum NO_x background concentrations occur in the western part of Central and Eastern Europe and in the western part of the former USSR. Seasonal patterns of NO_x are also characterized by summer minima and winter maxima. The range of seasonal variations is usually between a factor of one and a half and two. Background concentrations of NO_x have decreased from 1983 to 1989.

Heavy Metals

Atmospheric concentrations of lead (Pb) and cadmium (Cd) are also heterogeneous. Mean seasonal concentrations decrease generally in an easterly direction (*Figure 5.4*). Stable seasonal variations within an annual cycle could be observed in many background regions. Observations over several years show concentrations to be two to three times higher for Pb during the cold season and 1.7 to 2.8 times higher for Cd during the warm season. The concentrations of Pb and Cd have gradually decreased from 1983 to 1989.

The features of arsenic (As) distribution differ from Pb and Cd because anthropogenic As is linked mainly to nonferrous metallurgy, whereas Pb and Cd are more strongly linked to transportation and energy combustion. Spatial variations result chiefly from the influence of nonferrous metallurgy on background territories, but, on the whole, seasonal and annual As concentrations are not appreciable. According to multiyear measurements, the range of As concentrations for the European part of the former Soviet Union is between 0.4 and 1.6 nanograms per cubic meter. There are no distinct seasonal or long-term variations.

More than 95% of mercury (Hg) in the atmosphere is in gaseous form. Only a small amount of Hg is due to anthropogenic sources. In the region studied, the mean annual concentrations of Hg are rather stable and vary for a number of years within the range of 4.0 to 16.0 nanograms per cubic meter. No distinct trends are evident.

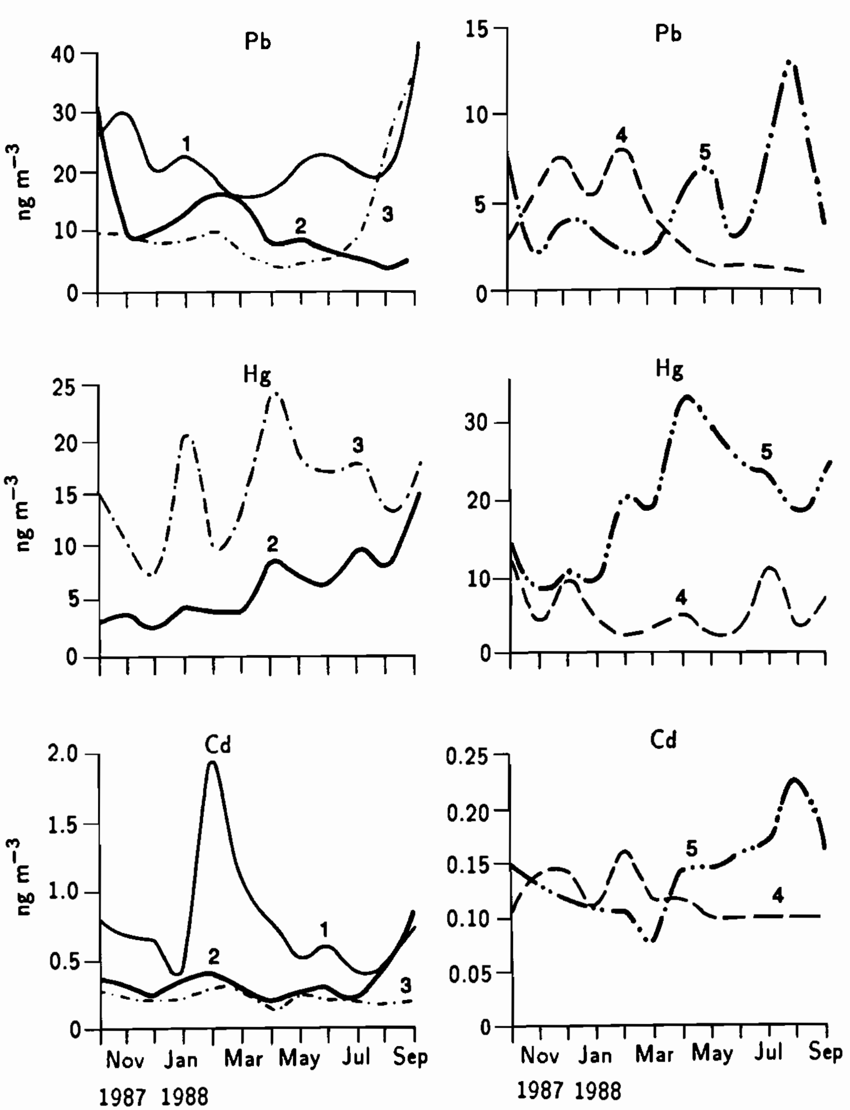

Figure 5.4. Mean monthly concentrations in the atmosphere at GEMS–IBMon stations of lead (Pb), mercury (Hg), and cadmium (Cd): (1) Eastern Europe (stations 51, 71, 73, 91); (2) former USSR (stations 2, 4, 11, 12, 13); (3) middle Asia and Kazakhstan (stations 1, 7, 8, 9); (4) Siberia (station 5); (5) former USSR high altitude (stations 3, 10).

Organochlorine Pesticides

The IBMon program measures DDT and its metabolites (DDE and DDD) and HCCH. The spatial distribution of DDT and HCCH is fairly even and can vary from 0.2 to 0.5 nanograms per cubic meter for DDT and from 0.4 to 1.0 nanograms per cubic meter for HCCH. Seasonal variations are low, but sometimes there are episodes of higher concentrations in spring and summer. Mean annual concentrations of DDT in the former European USSR show a decreasing trend with values in 1988–1989 being half those of 1981–1982.

Polycyclic Aromatic Hydrocarbons (PAH)

Measurements of 3,4-benzpyrene (BP) and other PAH compounds (1,12-benzperylene, BPL) are included in the IBMon program. The spatial distribution of BP resembles that of other primarily anthropogenic substances such as sulfur dioxide or lead. BP concentrations generally decrease eastward with background concentrations related to population density. BP has a distinctive seasonal trend. The summer minimum results from a decrease of emissions from its combustion sources, and from increased photochemical destruction of BP molecules. Seasonal concentrations of BP and BPL show no clear trend for the period of 1982–1989.

Data on concentration ranges of other PAH compounds are given in *Table 5.2*. All of the compounds in the table have spatial and seasonal variations, which is why their concentration ranges are noticeably wide. The ratios of PAH compounds are often correlated in the urban or background atmosphere but are uncorrelated in emission sources. For example, the ratios of BPL:BP in the urban and background atmospheres are 1.7 and 0.1 to 1.0 respectively, but in motor-vehicle and coal-burning exhausts their ratios are 13.0 and 0.8, respectively (Rovinsky *et al.*, 1988). The ratio BPL:BP in the background atmosphere is higher during the warm season than during the cold season because BPL is less susceptible to photochemical oxidation.

Table 5.2. The ranges of background concentrations of PAH compounds in the atmosphere over the former USSR.

PAH	ng m^{-3}
Phenanthrene	0.01–0.61
Chrysene	0.19–10.4
Tetraphene	0.01–2.77
Fluoranthene	0.12–4.02
Pyrene	0.05–7.80
3-methylpyrene	0.02–1.54
Ethylpyrene	0.01–0.86
Anthanthrene	0.01–0.88
Dimethylpyrene	0.02–0.55
1,2-5,6-dibenzanthracene	0.01–0.21
1,2-benzpyrene	0.04–0.74
3,4-benzfluoranthene	0.11–1.55
Perylene	0.01–0.40
Coronene	0.02–0.20

5.2 Background Contaminants in Precipitation

Estimates of pollutant content in precipitation and pollutant deposition are of great value in determining the atmospheric burden of pollutants to ecosystems in background regions. Observational data show a range of mean seasonal pH values between 4.0 and 6.5 (*Figure 5.5*). Weakly acidified precipitation (pH equal to 4.0 to 5.0) is characteristic of nearly the entire region, but acid rain occurs most frequently in the western part, particularly at background stations in the former GDR, the CSFR, Poland, and some stations in the former USSR. Relatively higher concentrations of sulfates and nitrates are usually observed in regions with more acid precipitation. Lower pH values (4.2 to 5.0) are noted in the peripheral areas of industrial regions with large sulfur emissions; northward and eastward from industrial centers in the Urals, around St. Petersburg, along the Finnish border of Russia, along the western border of the Ukraine and Byelorussia, and north of Kiev. In the Kola Peninsula, pH values lower than 5.0 are observed close to nonferrous metallurgy enterprises. In the Carpathians, acidification results from transboundary transport and covers almost the entire range.

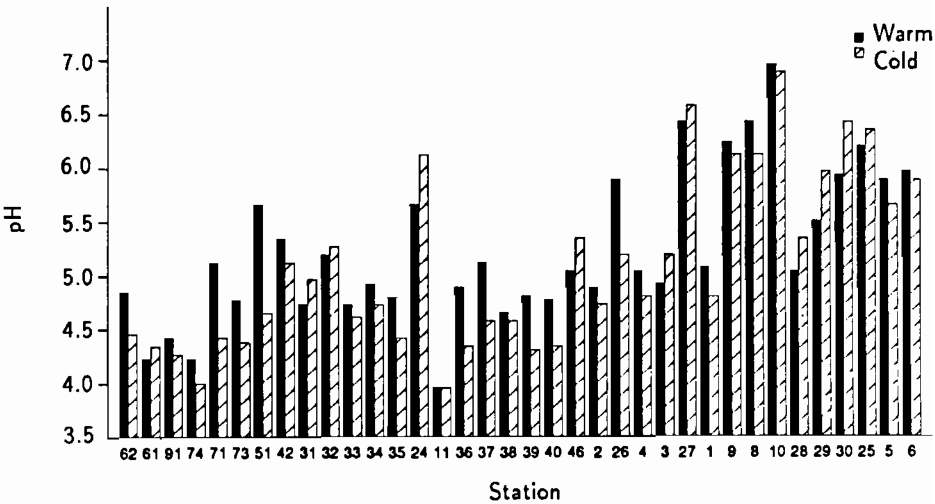

Figure 5.5. Mean weighted pH values for precipitation volume in warm and cold seasons measured at stations in *Figure 5.1.*

The pH of precipitation ranges between 5.0 and 5.5 over large territories in the northern part of the former USSR including the St. Petersburg region, Karelia, the Kola Peninsula, the Polar Urals, the Taimyr and Ob Gulf, northern Yakutia, and the Kolyma lowland. In western Siberia and the Ukraine, there are spots of higher acidity around the large industrial centers.

On the whole, pH values below the equilibrium value (pH equal to 5.6) are linked with sulfate and nitrate deposition, resulting from transport of pollutants hundreds of kilometers from industrial centers. Ranges of pH between 5.5 and 6.5 are found over major parts of the European territories of the former USSR, as well as western and eastern Siberia.

Precipitation with pH from 6.5 to 7.5 occurs in the vicinity of ferrous metallurgical plants and large power stations. In southeastern regions of the former European USSR and in Kazakhstan, alkaline precipitation results from transport of dust formed by erosion of saline soil and rock. Additionally, alkaline precipitation occurs in mountainous areas of the Caucasus, Middle Asia, Altai, central Siberia, and vast territories of the Far East.

Alkaline snow (pH equal to 7.5 to 8.0) is observed in local zones surrounding big industrial centers in Siberia and the Far East. Most of these zones are not presented on the map.

Heavy Metals

The spatial distribution of Pb and Cd in atmospheric precipitation is similar to that in the ambient atmosphere of background regions; there is a general eastward decline in concentrations. Maximum Pb and Cd concentrations are registered in background regions of Poland (16.0 to 64.0 and 0.3 to 1.1 micrograms per cubic liter, respectively). In the CSFR and Hungary, Pb concentrations are lower than Cd concentrations (8.2 to 13.0 and 13.0 to 26.0 micrograms per cubic liter, respectively). Still lower concentrations are observed in Bulgaria (Pb up to 5.4 micrograms per cubic liter; Cd up to 0.17 micrograms per cubic liter) and the former GDR (Pb up to 11.0 micrograms per cubic liter; Cd up to 0.42 micrograms per cubic liter). In most of the background regions of the former European USSR, the range of Pb concentrations is between 1.9 and 9.2 micrograms per cubic liter and that of Cd concentrations is between 0.1 and 0.7 micrograms per cubic liter. But in some regions, Pb concentrations in air and in precipitation are correlated. For example, Pb concentrations in precipitation at times reach 130 and 80 micrograms per cubic liter, correspondingly at Sniezka (Poland) and the Oka-Terrace (Russia) stations. No evident seasonal trends for Pb and Cd in precipitation were observed between 1981 and 1989.

The spatial distribution of As and Hg in precipitation is rather homogeneous, similar to that of their concentrations in the ambient air. As a rule, Hg concentrations are higher in warm seasons than in cold ones.

Organochlorine Pesticides and PAH

DDT and HCCH concentrations in precipitation are usually well correlated with ambient air concentrations. For example, maximum DDT concentrations both in precipitation (100 to 170 nanograms per liter) and in the ambient air were measured at European background stations in 1984–1985.

Table 5.3. Wet deposition fluxes in nanograms per square centimeter per year.

Pollutant	Western Europe	Former European USSR	Former Asian USSR	North America	Central and Eastern Europe
Lead	700.0	320.00	130.00	490.00	500.0 – 2000.0
Cadmium	25.0	21.00	4.00	33.00	18.0 – 120.0
Arsenic	100.0	62.00	26.00	35.00	–
Mercury	15.0	25.00	7.00	4.00	–
HCCH	1.6	1.90	0.80	0.40	6.0 – 7.0
DDT	1.9	2.70	0.70	0.10	10.0 – 11.0
3,4-BP	0.4	0.38	0.18	0.14	

Mean annual BP and BPL concentrations in precipitation are fairly even over the region. As a rule, PAH content in precipitation has a seasonal annual cycle that is similar to PAH content in air.

Pollutant Deposition

Pollutant fluxes to the environment can be calculated from the formula

$$F = ST(fw + fd) ,$$

where S is the area, T is the period of calculations, and $fw + fd$ are fluxes of wet and dry deposition, respectively. The value of fw is usually determined experimentally as the product of concentration and precipitation amount. The value of fd is seldom measured experimentally, often being calculated as the product of the ambient concentration and a deposition velocity. Errors in calculating fd values are not very important because the share of dry deposition in total deposition is usually only 15% to 30%, with the exception of polar regions, deserts, and semideserts. *Table 5.3* presents estimates of the wet deposition flux, fw, for different regions of the world.

The background stations in Central and Eastern Europe are located mostly in a zone of moderate precipitation (500 to 800 millimeters per year), excluding the station in the Caucasus Mountains (up to 2,000 millimeters per year). According to estimates from Suwalki (570 millimeters per year), the share of Pb and Cd dry deposition is 20% to 30% of the total annual flux.

The mean annual flux of Pb is 5 to 8 milligrams per square meter according to the data from K-Pusta, Kosetice, Berezina, and the Caucasus stations. At the background stations in Suwalki, Jarczew, and Oka-Terrace BR, the flux value is higher: 12 to 20 milligrams per square meter. The maximum flux is measured at Sniezka station: 60 milligrams per square meter.

The mean annual flux of Cd is 0.21 to 0.42 milligrams per square meter, and at the Sniezka station 1.2 milligrams per square meter. The mean annual flux of Cd is 0.18 to 0.37 milligrams per square meter. The annual fluxes of DDT and HCCH are rather even, ranging only between 100 and 110 and 60 and 70 microgramss per square meter, respectively.

5.3 Conclusions

These data are drawn from a system of background monitoring stations operating under the international IBMon, BAPMon, EMEP programs, as well as special assessments of background atmospheric pollution and precipitation based on multiyear observational data. The general conclusion is that the atmosphere is subject to anthropogenic pressure over vast territories, and that background pollution has not decreased with time. Hence, there is an urgent need to develop further the background monitoring system.

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Chapter 6

Transboundary Air Pollution in Central Europe and Eastern Europe

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Until now, most attention on air-quality problems in Eastern Europe has justifiably centered on the intense, local pollution that occurs in urban and industrial areas. Yet there is also low-level, but widespread, contamination of the surrounding rural areas caused by the long-range transport of air-pollutants; where borders intervene in the path of this long-range transport, a transboundary air-pollution problem occurs as well. This chapter presents a brief overview of the transboundary transport of air pollutants in Eastern Europe and its consequences on contamination within these countries.

6.1 Processes of Long-Range Transport of Air Pollutants

Under typical conditions, air pollutants are only partly removed from the atmosphere in the vicinity of their sources. Taking SO_2 as an example, Högstrom (1979) estimates that only about 8% to 21% of the SO_2 emitted by different cities are deposited within a 70-kilometer radius of the cities (under average meteorological conditions, and in the absence of precipitation).

Air pollutants that are not removed near their source are mixed into the lowest layer of the atmosphere. This so-called mixing layer typically extends from the ground to about 200 to 2,000 meters above the earth's surface. After mixing, the pollutants are transported by upper level winds until they are removed from the atmosphere as dry or wet deposition.

Dry deposition refers to the removal of contaminants by diffusion, air turbulence, settling, or other processes apart from precipitation. By dry deposition, pollutants may be absorbed into vegetation through their stomata or deposited onto the surfaces of soil or buildings. The rate of this deposition depends on the type of receptor surface, the amount of moisture on the receptor, the amount of turbulence in the lower atmosphere, and other factors.

Wet deposition of pollutants occurs when pollutants are incorporated into the different types of precipitation – rain, sleet, hail, or snow. The rate of wet deposition also depends on many factors including the type of precipitation and its intensity, as well as the form of the pollutant (whether it is a gas or particle). Another removal process, *droplet* deposition, can be important especially where fogs and low clouds occur. By means of droplet deposition, pollutants are incorporated into cloud or fog droplets and then removed from the atmosphere when these droplets come into contact with the earth's surface.

According to theoretical calculations, some pollutants can remain in the lower atmosphere a rather long time. For example, the mean residence time of sulfur in Europe's atmosphere is estimated to be about two to four days (see Rodhe *et al.*, 1982). Some types of heavy metals can also have fairly long atmospheric residence times because they adhere onto particles that are too small to quickly settle out, and too large to

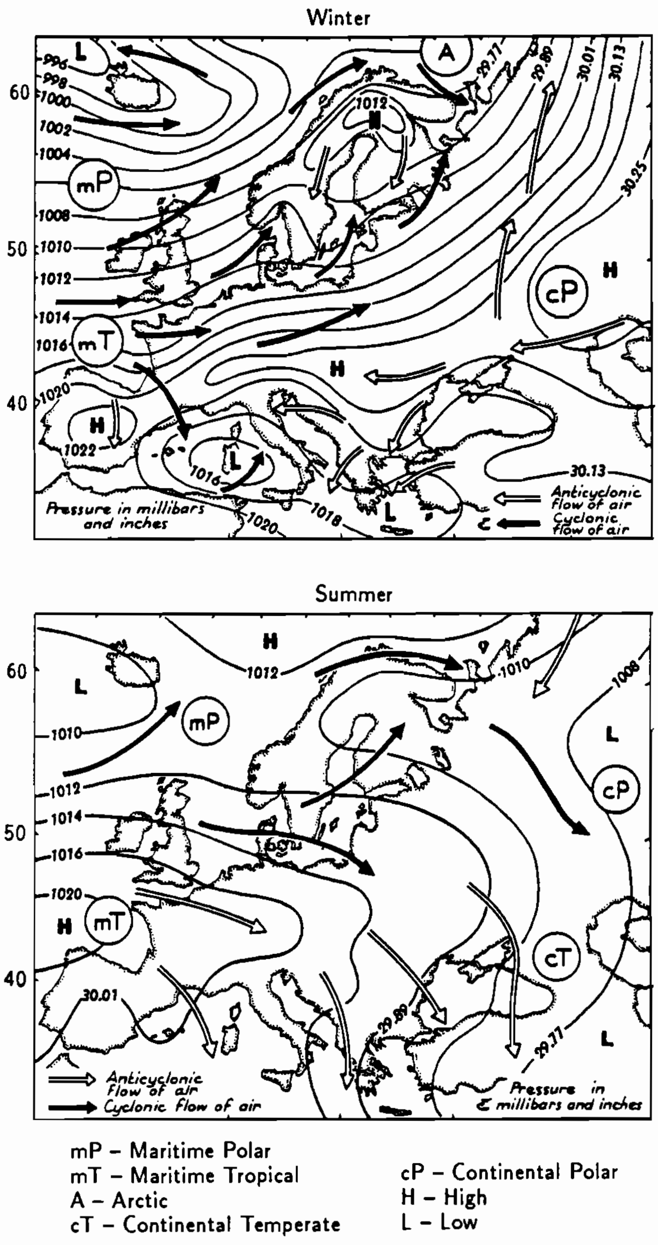

Figure 6.1. Typical meteorological patterns in Europe for winter and summer.

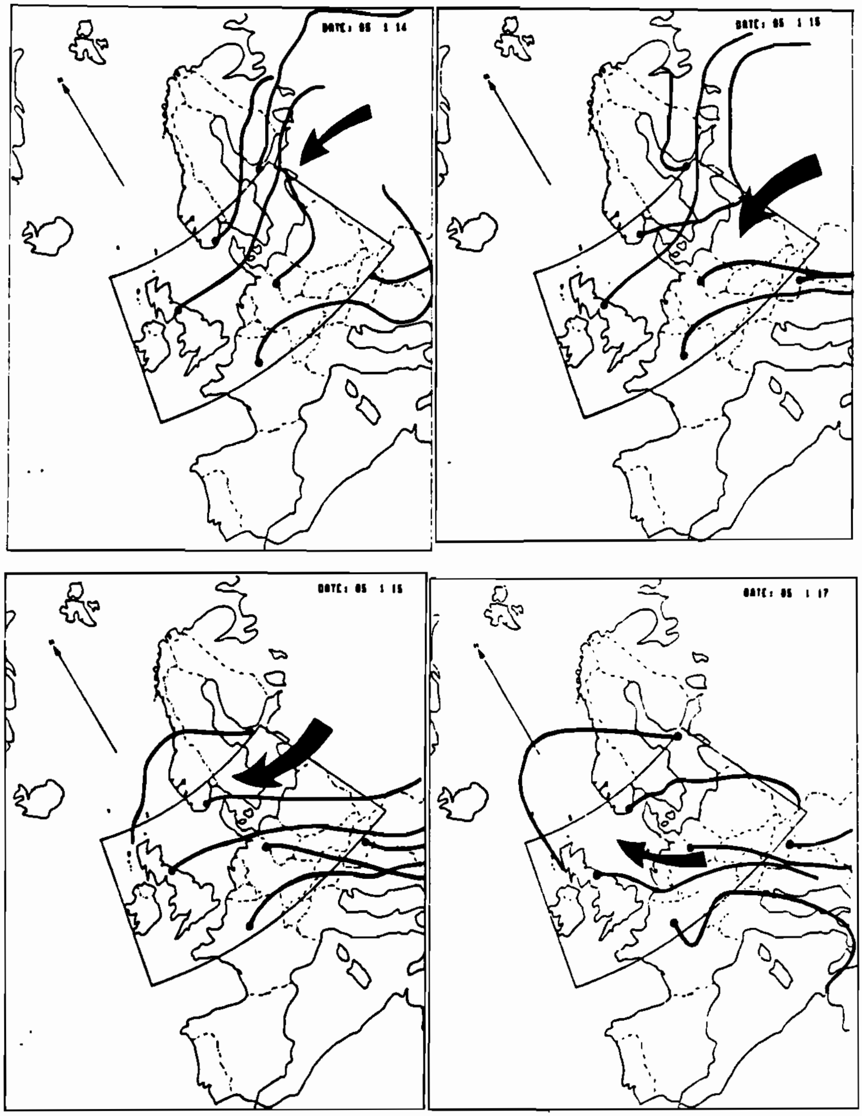

Figure 6.2. Air-mass trajectories at 850 hPa during SO_2 episode in mid-January 1985. Source: Lübkert, 1989.

be deposited by air turbulence. In Europe, the mean residence time of arsenic particles in the lower atmosphere is estimated to be about one day, and for lead about two and a half days (Alcamo *et al.*, 1991a).

This relatively long residence time translates into a long transport distance. Results from numerical models, trajectory analyses, tracer studies, and other analyses indicate that pollutants emitted by high-level sources such as smelters and power plants may travel as far as 1,000 to 2,000 kilometers before being deposited. In Europe, long-range transport of SO_2 has been well documented since the 1970s (OECD, 1979). Later it was found that other contaminants, such as nitrogen oxides, ammonia-nitrogen, and heavy metals, are also transported long distances (see, for example, Derwent and Nodop, 1986; Hanssen *et al.*, 1980).

The typical eastward wind pattern in Europe (*Figure 6.1*) implies that the main transport of pollutants is in this direction. However, two other important factors influence the net flux of pollutants. First, the density of emissions per unit area is much greater in most of Eastern Europe than in Western Europe. This is apparent from grid maps of European emissions produced by EMEP (European Monitoring and Evaluation Program) and other organizations (Iversen *et al.*, 1989). Second, stagnant or easterly wind conditions sometimes occur; at these times pollutants gather over Central and Eastern Europe and can be transported westward. For example, in the well-documented January 1985 SO_2 smog episode, pollutants accumulated in a stagnant air mass over Central Europe and were then transported to Western Europe by moderate winds blowing from the east (Lübkert, 1989). *Figure 6.2* shows that air masses traveling at high elevations during this episode originated mostly in Central and Eastern Europe. Owing to these factors, there is a flux of pollutants both eastward and westward (as well as north and south) in Europe. Whether this amounts to a net eastward or westward flow of pollutants is discussed in Section 6.2.

6.2 Quantifying Transboundary Air Pollution

In principle, there are several methods for studying the long-range transport of pollutants, including large-scale atmospheric tracer studies. However, because of the difficulty and expense in conducting these and related field experiments, it is more convenient to study the long-range transport of air pollutants by computer simulation. (Results from field studies can also be combined with computer models to study pollutant transport.) These models have many different designs, but they are similar in that they all represent key processes of transport and deposition of pollutants in the form of mathematical equations. As input, they employ emission estimates and meteorological data such as winds and precipitation. As output, they compute short- or long-term air concentrations and deposition in a grid over Europe. The accuracy of these models vary depending on the type of model, the quality of input data, the averaging time of results, and other factors. For instance, the accuracy of one frequently used long-range transport model, the EMEP model of sulfur and nitrogen in Europe, is often said to be within a factor of two of monthly or annual average point measurements of air concentration and deposition (see, for example, model results in Iversen *et al.*, 1989.)

Various computer models have been used to estimate the atmospheric flux of different substances between European countries. Results from the EMEP model indicate a net westward flux of atmospheric sulfur (*Figure 6.3*). This implies that the high-density emissions from the east backflow to the west, against the prevailing winds.

Since it is well known that pollutant emissions from the east affect the west, we move on now to the less-noted problem of transboundary air pollution within Central and Eastern Europe itself. We initially focus on sulfur and nitrogen because they are the main constituents of acid deposition in Europe.

Figure 6.4 indicates that there is an important exchange of acidifying pollutants between countries. As to the net direction of this flux within Eastern Europe itself, sulfur follows the prevailing winds eastward. This is because substantial amounts of sulfur are emitted nearly everywhere in Eastern Europe, and hence there is no substantial backflow of pollutants within Eastern Europe as there is from Eastern to Western Europe. Poland, for example, receives a much greater amount of sulfur across its western border than it sends across this border. In the same way, Poland contributes considerably more sulfur to its eastern neighbors than it receives from them. This flux, however, is a function of the size of the receptor country; a small country will receive fewer

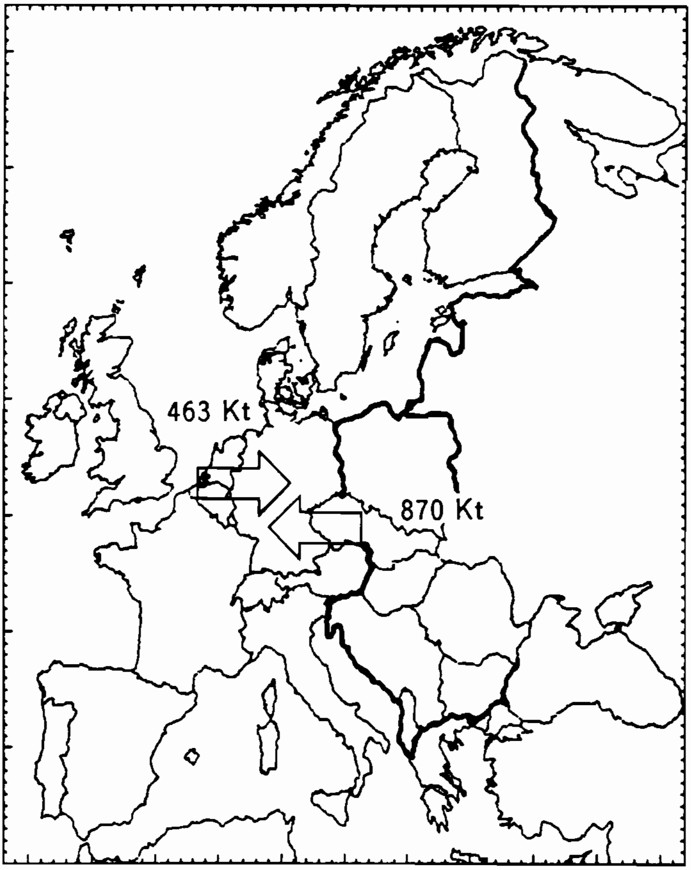

Figure 6.3. Estimated annual east–west flux of sulfur in Europe's atmosphere in 1985. Source: Iversen *et al.*, 1989.

kilotons of sulfur on its territory than a large country, all other factors being equal.

The annual flux of nitrogen (as the sum of nitrogen oxides and ammonia-nitrogen) also shows a general trend toward the east. However, the total mass of nitrogen is not as great as the mass of sulfur.

In addition to the acidifying pollutants of sulfur and nitrogen, there are also relatively large quantities of other more toxic pollutants emitted to the atmosphere in Central and Eastern Europe such as heavy

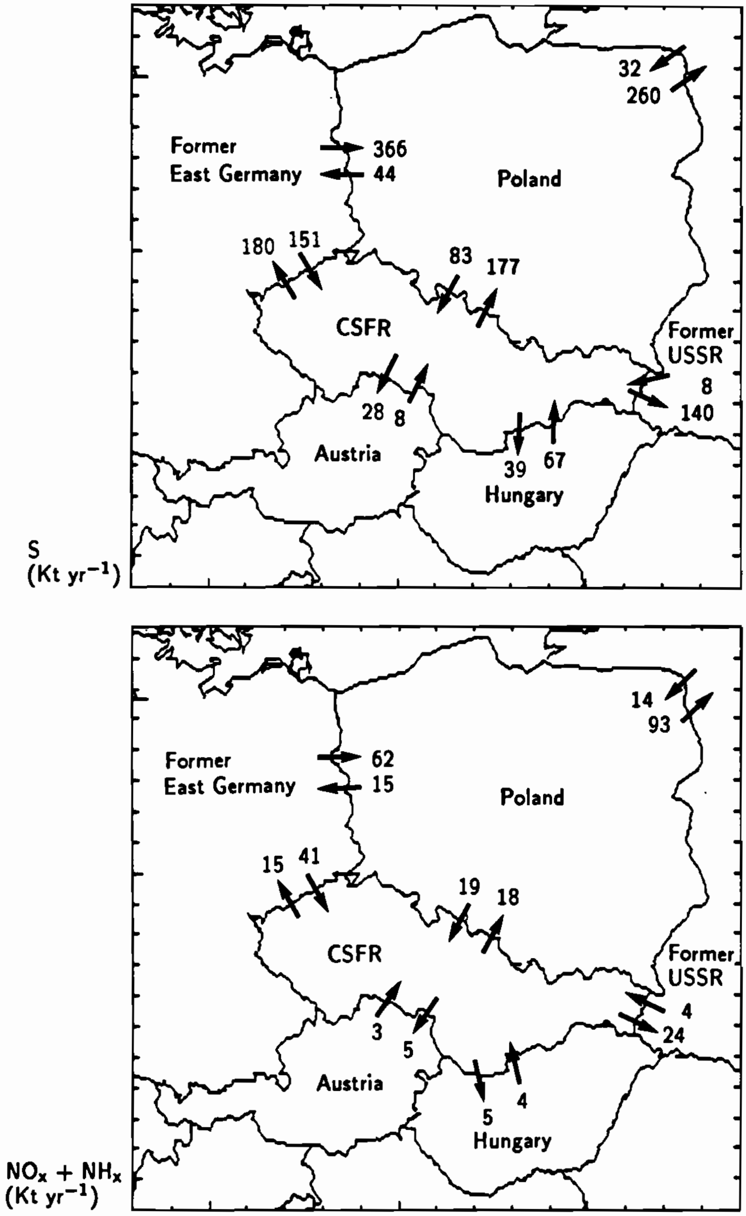

Figure 6.4. Atmospheric flux of sulfur (S) and nitrogen (NO_x + NH_x) in 1985 between countries in Central Europe. Source: EMEP data.

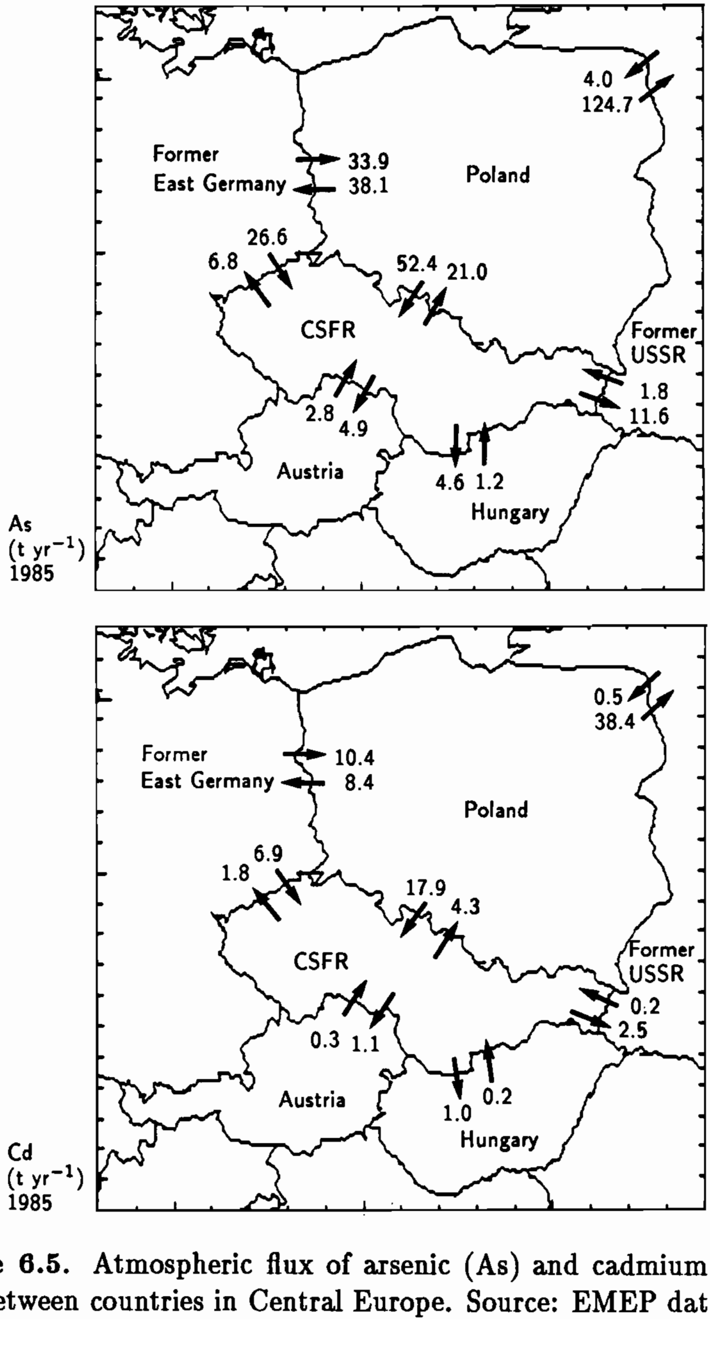

Figure 6.5. Atmospheric flux of arsenic (As) and cadmium (Cd) in 1985 between countries in Central Europe. Source: EMEP data.

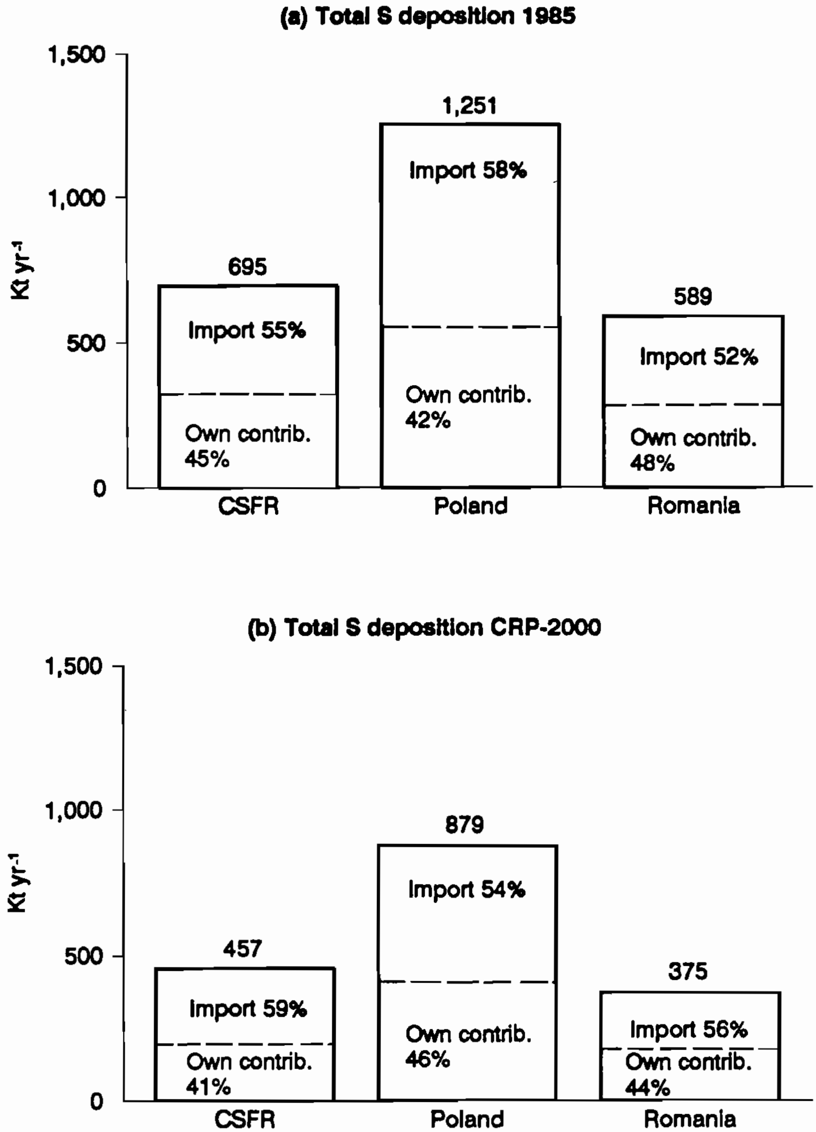

Figure 6.6. Budgets of atmospheric loads of sulfur (S) to selected Central and Eastern European countries: (*a*) 1985 and (*b*) 2000 under SO_2 Current Reduction Plans (CPR-2000). Sources: Iversen *et al.*, 1989; Alcamo *et al.*, 1990.

metals. These substances are emitted as gases or small particles from power plants, metallurgical smelters, vehicles, and other sources, and, as noted above, can remain in the atmosphere 24 hours or longer. Computer models have been used to estimate the flux between countries of these toxic pollutants. Computations of arsenic and cadmium using the TRACE model (Alcamo *et al.*, 1991b; Bozó *et al.*, 1991) show that there is a substantial transboundary flow of these substances (*Figure 6.5*). A fairly even exchange of As and Cd takes place between Poland and former East Germany, but between other countries the flow is much less balanced.

Another way to examine the extent of transboundary air pollution is to compute the origin of the annual average atmospheric loads of these substances to a particular country. Computing pollutant fluxes in this way confirms that a substantial amount of the atmospheric flux of sulfur originates outside of the country. For example, more than 50% of the load to the CSFR, Poland, and Romania comes from outside their respective borders [*Figure 6.6*(*a*)]. This is despite the fact that these countries are among the largest contributers of sulfur dioxide to Europe's atmosphere. Taking into account expected reductions of SO_2, the same situation will apply in the year 2000 [*Figure 6.6*(*b*)].

In examining the situation for arsenic, we compute that the greater part of the atmospheric load to Albania, the CSFR, Hungary, and Romania originate outside their borders (*Figure 6.7*). Indeed, each country in Eastern Europe receives an appreciable amount of its arsenic load from its neighbors.

6.3 Discussion and Conclusions

Thus far we have seen that the long-range transport of air pollutants results in a significant transboundary exchange, not only between east and west but also between the different states in Eastern Europe. We have not, however, mentioned the consequences of the widespread pollutant deposition to rural areas that results from long-range transport of pollutants. In rural Eastern Europe the impacts of acid deposition include large-scale soil acidification and forest dieback (see, for example, Nilsson, 1991), as well as groundwater contamination and reduction of the vitality of different ecosystems (see ECE, 1984; Chadwick and

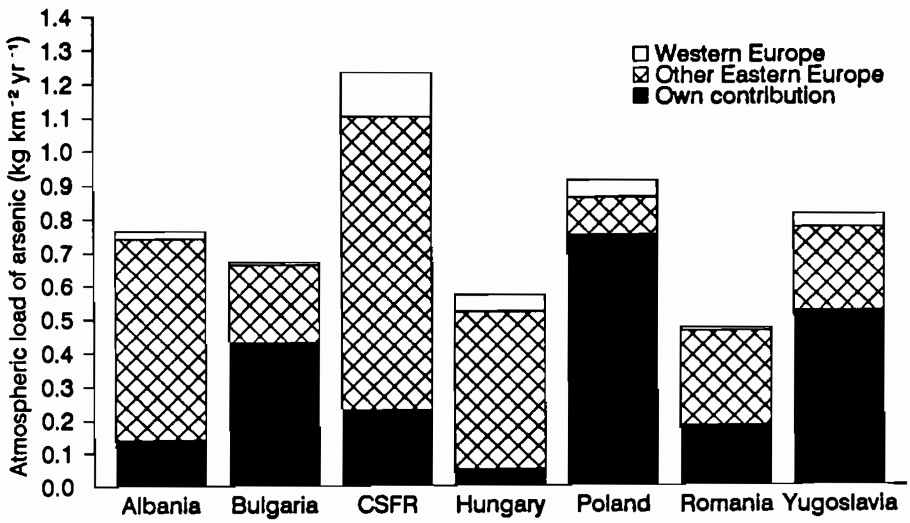

Figure 6.7. Budgets of atmospheric loads of arsenic to Eastern European countries, mid-1980s conditions. Source: Bozó *et al.*, 1991.

Hutton, 1991; Alcamo *et al.*, 1990). These impacts are observed far from SO_2 and NO_x emission sources; close to these sources there is also a risk to public health.

The temporal dimension of these problems is also noteworthy. In the case of acid deposition, it is known that even a relatively low flux of acidifying substances can slowly erode the ability of the environment to neutralize these acids. Consequently, soil acidification can intensify even if the net flux of acid deposition is reduced over time. This is illustrated by calculations from the RAINS model, which takes into account the link between emissions, long-range transport, and sensitivity of soils in Europe (Kauppi *et al.*, 1990; de Vries *et al.*, 1989). The model estimates that the area of soils in Central Europe with pH less than 4.0 will increase from about 5% in 1980 to 45% in the year 2040 (*Figure 6.8*). Moreover, these calculations assume that emissions will level off or be curtailed under a policy of Current Reduction Plans. In these simulations soil acidification intensifies despite the reduction in acid deposition because the natural reserves of neutralizing chemicals in soils are gradually depleted.

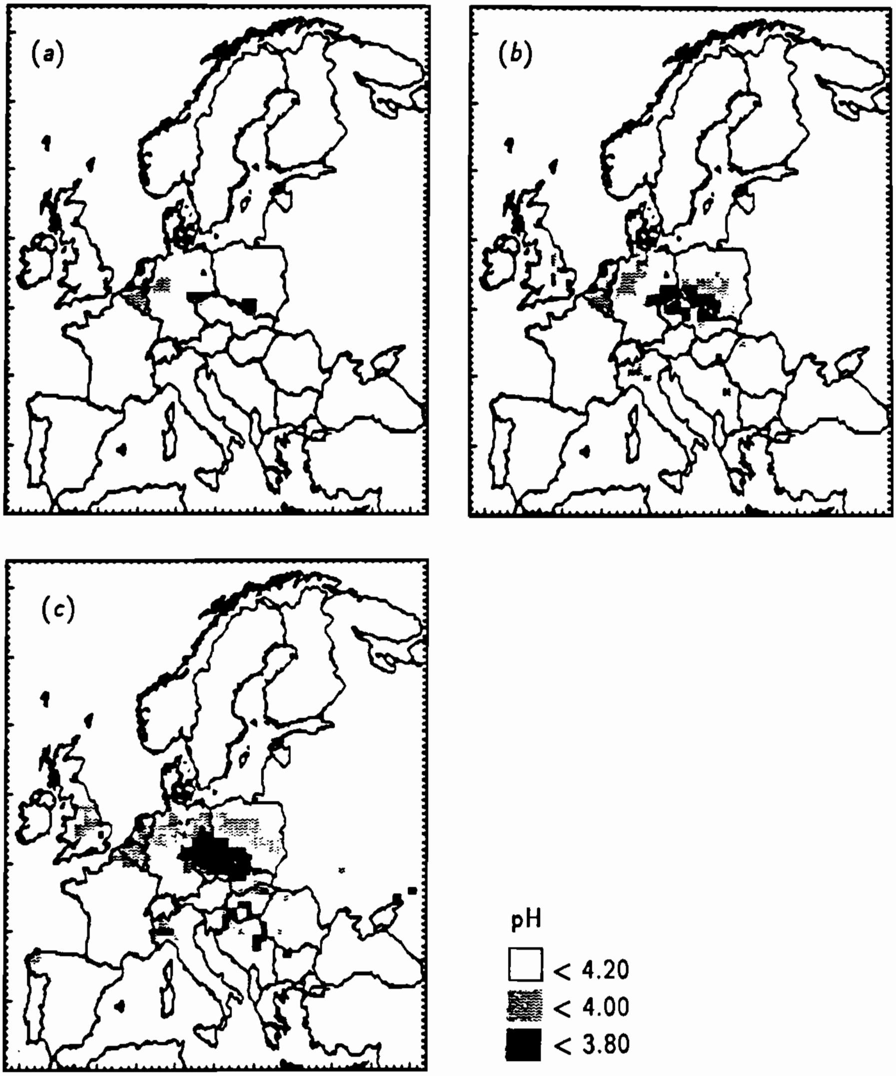

Figure 6.8. Calculated soil pH in Europe: (*a*) 1980; (*b*) Current Reduction Plans, year 2000; (*c*) Current Reduction Plans, year 2040. Source: Alcamo *et al.*, 1990; Kauppi *et al.*, 1990.

The deposition of heavy metals to rural areas of Central and Eastern Europe have also been calculated (Alcamo *et al.*, 1991b; Bozó *et al.*, 1991). It was estimated that the deposition of arsenic, cadmium, lead, and zinc to these areas are at least one order of magnitude (in some cases three orders of magnitude) over their level in remote regions. The consequences of this widespread, low-level contamination have yet to be fully examined.

In summary, the data show that air pollution is more than a local problem, even in Central and Eastern Europe where local emission sources are intense. Because air pollutants can remain one or more days in the atmosphere, they can be transported more than 1,000 kilometers from their source. This leads to a widespread, low-level contamination of rural areas in Central and Eastern Europe. As pointed out, the cumulative effects of this low-level contamination can be significant. However, these conclusions do not take away from the need for each country to give highest priority to its own local and severe air-pollution problems. But they do indicate that air-pollution problems within a country cannot be fully solved without taking into account the exchange of pollutants across its borders. From this perspective regional cooperation is more than a political gesture; it is also a sound strategy for restoring the environment.

Acknowledgments

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Chapter 7

Water-Pollution Problems and Priorities in Bulgaria

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7.1 A Review of Bulgaria's Water-Pollution Problems

Bulgaria is a country comparatively poor in water resources. Inland surface waters amount to 19.597 billion cubic meters per year. Undrained groundwaters occupy 1.52 billion cubic meters. With 83% of the population being supplied, the problem of drinking water has been solved in a fairly satisfactory way, providing an average of 220 liters per person per day.

Industry consumes 1.6 billion cubic meters yearly (180 cubic meters per capita). This means that Bulgarian industry consumes too much water. Hydropower production uses some 3 billion cubic meters annually. Irrigation in agriculture is the biggest consumer of water – 1.2

million hectares of irrigated land uses up to 3.8 billion cubic meters of water in a normal year.

Total water consumption is about 9.12 billion cubic meters annually. Effluents are about 1.6 billion cubic meters, of which approximately 60% is recycled. Larger settlements have water mains and sewage systems, and 40% of these have water-purifying stations. Regrettably, the purifying facilities in residential and industrial areas cannot guarantee the cleanliness of the river basins.

The quality of surface waters in 15 river basins, the Bulgarian section of the Danube River, and the Black Sea coast is monitored in 208 locations as part of the national Environmental Monitoring and Information System (Sadovski *et al.*, 1990). The following indicators are monitored: water quantity, temperature, active reaction pH, electrical conductivity, dissolved oxygen, dissolved substances, suspended matter, hydrogen sulfide, ammonia, nitrates, phosphates, chlorides, sulfates, the five-day biochemical oxygen demand (BOD-5), permanganate oxidization, iron, manganese, cadmium, chromium, arsenic, lead, copper, zinc, detergents, oil products, and others. Data about the quality of surface waters are published in a quarterly bulletin (ERIC, 1974–1990) and are used for assessing their state (Bonev and Miloushev, 1989).

The largest polluter is the chemical industry followed by the ore-extraction industry, the metallurgy industry, the food and beverage industry, and the cellulose and pulp industry. Agriculture and coal mining also contribute. The quantity of effluents is highest in the basins of the Provadiiska, Maritsa, Iskur, and Arda rivers, and lowest in the Veleka. The quantity of liquid pollutants exceeds that of solid pollutants in all basins except the Arda. This is due to the lack of water-recycling systems in a number of ore-extraction and ore-dressing enterprises located there.

Groundwater quality is monitored at a total of 276 sites. Samples are collected one to twelve times per year to check eight quality parameters: sulfates, chlorides, nitrates, total iron, total mineral content, permanganic acidity, magnesium, and hardness.

Major regional-level pollutants include nitrates in Loudogorie, Dobrudja, Yambol, Haskovo, and Plovdiv; sulfates in Sofia, Plovdiv, and Bourgas; chlorides in the Danube and Black Sea coastal areas; magnesia and high mineral content in Plovdiv, Stara Zagora, and Dobrudja.

Manganese has been detected in waters from river terraces along the Maritsa, Tundja, Danube, Ogosta, and other rivers.

The Struma River. A total of 165 sources discharge 218,000 cubic meters of wastewater per day into the basin. Pollution comes from domestic sources, utilities, and industries in Pernik, Radomir, Stanke Dimitrov, and Blagoevgrad, from livestock wastes, from agricultural fertilizers, and from accidental releases of a pharmaceutical plant in Stanke Dimitrov. Critical concentrations of BOD-5 in wastewater have sometimes been exceeded by a factor of 100. Oil-product residues pollute the entire basin.

The Mesta River. Major polluters in the basin include municipalities, industries, and cattle farms. In 1989 these sources generated a wastewater flow of 89,689 cubic meters per day. The worst affected river in the basin is the Razlozhka on the outskirts of the town of Razlog. Acidity, BOD-5, insolubles, lubricants, and oil products are considerably above critical concentrations. Acidity, for instance, is 2.5 times above critical values. Oil products are a major wastewater-treatment problem.

The Maritsa River. The highest wastewater loads have been measured downstream from Pazardzhik (16% of the river flow), Stamboliiski (11%), Plovdiv (23%), and Dimitrovgrad (13%), and downstream from the mouth of the tributary Sazliika (27%). Ammonia ion concentrations exceed critical levels by up to 10 times in several sections of the river. High concentrations of nitrate ions have been measured downstream from Dimitrovgrad. Heavy metals have been detected downstream from Pazardzhik and at the mouth of the tributary Chepelarska. Process water from the G. Damyanov Metal Works in Srednogorie (which carry high concentrations of arsenic and other pollutants) is released into the Topolnitza River (a tributary of the Maritsa). Arsenic concentrations in Topolnitza are 20 to 50 times above critical levels.

The Iskur River. One of the biggest polluters in the country, Sofia, is situated in this basin. Some 70% to 75% of the overall pollution load on the Iskur (and several of its tributaries) comes from Sofia's sewage system. Water quality is substandard downstream from Sofia. On the average, the level of BOD-5 is three to five times higher than the estimated critical level. Levels of phenols and cyanides are two to three times above the critical level. The Sofia municipal wastewater-treatment station functions relatively well. Nevertheless, no significant improvement of water quality has been measured. The Krenikovtzi Iron and Steel Works are a major polluter of the Iskur's tributary, the Lesnovska. Downstream from Eliseina, lead and cadmium exceed critical concentrations by a factor of two. Oil-product residues pollute the entire basin.

The Osum River. The towns of Troyan, Lovech, and Levski do not have sewage-treatment facilities. This results in concentrations of BOD-5 and other insolubles two to three times above critical levels.

The Yantra River. Measurements show considerable organic pollution, and dissolved oxygen content is below normal. The concentrations of insolubles, BOD-5, acidity, and ammonia nitrogen are twice the critical levels. Downstream from the town of Gabrovo, the concentration of oil products is about 20 milligrams per liter; the norm is 0.3 milligrams per liter. Measurements have recorded hydrogen sulfide concentrations of up to 1.5 milligrams per liter. Downstream from Dolna Oryahovitza, BOD-5 pollution is considerable, and insolubles and acidity reach up to five times above the critical limits. Water quality at the river's mouth is altogether poor.

The Kamchia River. Water quality in the Luda Kamchia River conforms to national standards. The Golyama Kamchia River, downstream from Preslav, does not conform to standards on BOD-5 and ammonia. Due to self-purification, the Kamchia River meets minimum standards by the time it flows into the Black Sea.

The Rousenski Lom River. The river basin is affected by large industrial and domestic polluters. Effluents from the Razgrad municipal treatment station deviate by a factor of two to ten from national standards. Process water of 8,800 cubic meters per day from the Razgrad antibiotic plant flows into a clarification unit and after 24 hours is released into the sewage system. In the Razgrad region, untreated wastewaters from a pig farm flow into the Beli Lom River and account for 50% of the organic matter and ammonia polluting the river.

The Danube River and the Black Sea. Analyzing the results of the monitoring of the Bulgarian section of the Danube (Boychev *et al.*, 1990) the following conclusions have been reached:

- River quality depends mostly on the quality of the river before it reaches Bulgaria.
- Overall pollution by inorganic substances has increased in the past 30 years.
- With some exceptions, the concentration of measured toxic substances is insignificant.
- Significant differences exist in the quality of the Danube's waters in its Bulgarian reach, its Romanian reach, and further downstream.

The Ministry of Environment has information on levels of pollution in the Black Sea from sources on Bulgarian territory. This forms about 3% of the total wastes carried into the sea by the Danube. No information is available on pollution from the Ukraine, Russia, and Georgia, but qualified estimates suggest at least the same load as that from the Danube.

No information is available on water quality in the canal flowing out of the Danube at Cherna Voda. Given that the Danube delta is a natural biological filter and is farther along the coast from Bulgaria than the canal, the assumption can be made that higher concentrations of biogenic elements off the Bulgarian coast are due to water flowing in from the canal.

In 1985, Bulgaria signed the Declaration of Co-operation between the Danubian States regarding the water resources of the Danube and its protection from pollution, in particular. It has since regularly met its obligations to this declaration. Bulgaria has undertaken various initiatives to protect the Danube both unilaterally and within the framework of programs adopted by international governmental and nongovernmental organizations.

7.2 Priorities in Controlling Water Pollution in Bulgaria

The pollution of ground and surface waters in Bulgaria and of the Black Sea's coastal waters depends on the quantity of effluents discharged in rivers and water basins. Some 4,100 sites have been registered as water polluters in a computer file. Studies have shown that 75% of the monitored length of the rivers in Bulgaria are polluted (that is, contain polluting agents above the norms allowed). Of all 15 river basins, only one (the Veleka River) is not polluted. The Maritsa, Provadiiska, Iskur, and Struma rivers are the most polluted (Bojinov *et al.*, 1988). Some of the groundwaters have a higher content of nitrates than normal.

Water quality is also poor in the Danube and the coastal area of the Black Sea. The high level of hydrogen sulfide in the Black Sea, as well as its eutrophication and decreasing oxygen content, creates serious problems.

Protecting the purity of waters has a high priority in state policy and is reflected in the National Programme for Protection and Restoration of the Natural Environment until the year 2000 (Project, 1989). The following measures are recommended to solve these problems:

- In view of the considerable shortage of water anticipated toward the year 2010, to restructure the economy immediately and orient it to new water-saving methods of production.
- To adopt new norms of water consumption that correspond to the actual needs of industry and agriculture.
- To create a new system of economic incentives and sanctions (taxes and fees) for water consumption and tapping effluents by classes and water economy regions.
- To concentrate water-intensive production in areas abundant in water to avoid the costly transfer of water from one river basin to another.
- To provide lower quality water to users such as industries that do not require water of drinking quality.
- To regulate water sources in catchment areas by afforestation, building reservoirs, and other measures.
- To introduce recycling water-supply systems, low-water and waterless technologies, nonwaste technologies, and similar measures.

- To install local industrial and sewage-treatment facilities.
- To organize industrial production and repair of filters and water-treatment facilities.
- To establish the technical base of a water-monitoring network as a subsystem of the national Environmental Monitoring and Information System.
- To improve the water quality and use cadastre.
- To develop the Blue Danube Project with the help of UNESCO.
- To continue activities on the ECE European Framework Convention on Transboundary Water Courses.

Bulgaria takes particular interest in the Convention on the Protection of the Black Sea, currently under preparation with Bulgaria's active support.

7.3 A National Environmental Monitoring and Information System for Bulgaria

In 1975 the State Council of the People's Republic of Bulgaria approved guidelines for a Unified National System for Monitoring and Information Concerning the State of the Environment which formulate the tasks, objectives, and structure of the system. On the basis of this concept the Committee on Environmental Protection (CEP), with the Ministry of Public Health and the Department of Hydrology and Meteorology at the Bulgarian Academy of Sciences, organized a network of stations for monitoring air and surface-water pollution.

The air-pollution monitoring system encompasses 93 stations. The following pollutants are measured according to mutually accepted schedules and methods: dust, sulfur dioxide, nitrogen dioxide, hydrogen sulfide, phenol, lead aerosols, and other pollutants. Monitoring of surface waters is conducted at 208 locations in 14 river basins, the Danube, and the coastal waters of the Black Sea. The quality of the water is assessed according to the following indices: transparency, color, temperature, reaction pH, dissolved oxygen, oxidization, dissolved substances, undissolved substances, content of nitrates, sulfates, phosphates, heavy metals, oil products, and others. Samples are taken and analyses are carried out at chemical laboratories in the Department of Hydrology and Meteorology, in the Hygiene and Epidemiology Inspections Office, and in Regional Inspections on Environmental Protection Department. The data are entered on special forms and sent for input and storage at the computer center of the CEP every three months. A quarterly bulletin is published after processing these data.

An information system about the content of heavy metals in soil has existed since 1980. It collects data from 240 sampling sites across the country. The radiation background has been monitored by a central laboratory and seven zonal laboratories of the CEP, but the data have not yet been published.

Records of all industries – more than 6,000 – that pollute the air and waters are kept in a computer file with data about the type and quantity of pollutants, characteristics of filters and water-treatment facilities, and so on. Thus a large database with valuable information exists, providing services to state bodies, research institutes, and other organizations. It also assesses and forecasts ecological conditions.

The existing information system fails to meet current demands. It cannot ensure timely, precise, and complete information about the quality of the environment and is inadequate for development of short-term and long-term prognoses and for current decision making. There is a lack of information on certain pollutants, particularly noise, super high-frequency, and electromagnetic fields. The system uses very low-level technology. At present only two automated air-monitoring stations are in operation (Varna and Burgas) and two local stations are in operation for water control along the Iskur River. The CEP's computer center (EC-1020) is obsolete and ineffective. Running as it has since 1974, it can no longer function as an automated system's key facility. There are no hardware and software tools for graphics or presentation of information and for automated cartography. A new approach and new measuring instruments are needed, coupled with new computing and communication facilities, integrated software, mathematical models, and ecology–economy models.

The Ministry of Environment now faces the task of establishing and further developing a fully functional national Environmental Monitoring and Information System (EMIS). Its purpose will be to provide timely and accurate information about the environment, with the help of sophisticated equipment; to make analyses, assessments, and short- and long-term prognoses; to give decision support; and to optimize all environmental protection activities at the regional and national levels.

Objects of monitoring and control include components of the environment: air, water, soil, ecosystems, waste products, radioactivity, and so on. Structurally the system is designed as a distributed and hierarchical system with three levels:

- Networks of monitoring stations and points.
- Regional dispatching coordination units.
- Central dispatching unit.

Monitoring stations and points are of two types: automatic measuring devices and manual sampling and laboratory analyses. The chief priority now is the delivery of complex automatic stations for control of ambient air in the cities of Bulgaria.

Another priority is equipment for a central dispatching unit including personal computers, graphics workstations, and ARC/INFO (a specialized application software package). Plans have been developed to link this unit by satellite with the German Federal Environmental Agency in Berlin and the European Monitoring and Information System.

A third priority is delivery of equipment for the automated water-monitoring network and for the central laboratory of the Ministry of Environment. Modern instruments are needed for analysis of samples of air, ground and surface waters, wastewaters, soils, and plants. Other prime necessities include portable sampling and measuring devices as well as laboratory equipment for environmental analyses at regional inspection centers.

The following documents about the monitoring program are available (in Bulgarian): *Environmental Monitoring and Information System: General Definition and System Design*; *Network for Monitoring of Air Pollution*; *Network for Monitoring Water Pollution*; *Land/Soil Monitoring*; *Natural Ecosystems Monitoring*; and *Radioactivity Monitoring.*

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Chapter 8

Air Pollution and Solid Waste in Bulgaria: Problems and Priorities

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The ecological crisis is one of the worst legacies of totalitarian rule in Bulgaria. To establish a market economy that is able to sustain long-term development and ensure sustainable environmental protection, it is necessary to assess the ecological crisis in the whole country and its separate regions and to analyze its causes.

8.1 Air Pollution

The large-scale nature of air pollution in Bulgaria was first recognized during the 1980s. In the 1970s air pollution was still considered a local problem. Its transboundary aspects have been recognized by the public only recently, after dangerous episodes of air pollution in neighboring countries and especially after the Chernobyl tragedy.

Table 8.1. The air-pollution situation in Bulgaria.

	Pollutant emissions[a]		Area in Bulgaria above PC[c]		Area in Bulgaria above 0.3 PC[c]	
District	(tons km^{-2})	Ratio (%)[b]	(km^2)[d]	Ratio (%)[e]	(km^2)[f]	Ratio (%)[g]
Sofia (city)	240.69	737.41	2,462	206.15	3,215	269.27
Haskovo	118.84	364.09	4,059	29.27	7,110	51.28
Sofia (district)	47.35	145.07	1,958	10.26	8,577	31.98
Varna	36.20	107.84	359	3.01	1,808	15.17
Burgas	7.05	21.60	2,826	19.27	2,826	19.27
Lovech	6.20	19.00	336	2.21	1,481	9.75
Mihailovgrad	4.95	15.17	183	0.73	713	4.08
Plovdiv	4.89	14.98	4	0.03	25	0.18
Razgrad	4.24	12.99	20	0.18	80	0.55
Bulgaria	32.64	100.00	12,207	11.00	25,814	23.27

[a]Includes SO_2, H_2S, NO_2, dust, and other contaminants.
[b]Ratio of flux in district to national average flux.
[c]PC – permissible concentration.
[d]Area in Bulgaria above PC caused by emissions from district.
[e]Ratio of area above PC to area of district.
[f]Area in Bulgaria above 0.3 PC caused by emissions from district.
[g]Ratio of area above 0.3 PC to area of district.

Monitoring data are published in an official bulletin on environmental quality, and a data bank has been organized in the scientific and information center of the Ministry of Environment. The bulletin contains monthly and annual maps, lists of short-term concentrations and their frequencies, information on maximum and average 24-hour concentrations, and other statistical data.

Rather than presenting maps and statistics, this chapter takes another approach and defines the territories that are exposed to continuous air pollution. *Table 8.1* presents data on emissions and concentrations in the country's nine districts. The table reveals that in four districts the flux of total air-pollutant emissions is above the national average. These four districts, together with the Burgas district, pollute large areas. Emissions from Sofia pollute a territory twice as big as the city itself. The table shows that pollution is unevenly distributed and mainly connected with the industrial development of a particular region. A major

Table 8.2. Air-quality standards.

Pollutant	Maximum hourly concentration ($\mu g\ m^{-3}$)	Country
Dust	0.100	Sweden
	0.200	Japan
	0.500	Bulgaria, former USSR
	0.600	Spain
	0.750	Italy
SO_2	0.260	Japan
	0.500	Bulgaria, former West Germany, former USSR
	0.625	Sweden
	0.750	Italy, Romania
	0.800	Spain
H_2S	0.080	Bulgaria, former USSR, CSFR
	0.010	Spain
	0.015	Former East Germany
	0.030	Romania
	0.050	Former West Germany
	0.100	Italy
	0.150	Finland
	0.300	Hungary

conclusion from *Table 8.1* is that air pollution exceeds permissible levels in 11% of Bulgaria and exceeds 0.3 times permissible concentrations in 23% of its territory. More importantly, over 40% of the country's population lives in these territories.

The concentration standards used for the preparation of *Table 8.1* are in accordance with the standards of former socialist countries and well in line with those accepted in more advanced countries. *Table 8.2* presents pollution standards for dust, SO_2, and H_2S in selected countries.

The acute air-pollution problem is mainly caused by aging and obsolete industries and the total mismatch of supplies of raw materials, energy, and natural resources. In 1985 over 3.62 million tons of different pollutants were emitted in Bulgaria. If an even distribution is assumed, this means 32.64 tons from each square kilometer (*Table 8.1*).

The single biggest pollutant is SO_2 with 71% of total emissions (2.6 million tons). Next comes dust emissions, amounting to 0.680 million tons per year, 19% of the total. Emissions of NO_2 are approximately 0.2 million tons, or about 6% of the total.

The sources of Bulgaria's air pollution are varied, but most of the emissions come from energy production: 0.8 million tons per year of dust (89.9% of total emissions) and 2.07 million tons per year of sulfuric and nitric oxides (74% of the total). All energy-production sources emit 2.7 million tons per year (74% of total emissions). Metallurgy takes second place with 30 million tons per year of dust (5%) and 581 million tons per year of sulfur and nitric oxides (21%); emissions from metallurgy equal 612 million tons per year (17%) of total emissions. The third major polluter is automobile transport with 4% of the total, followed by the chemical industry with 3.5%. The construction industry accounts for nearly 1%, while the pulp and paper industry produces 0.4% of total emissions.

The Stockholm Conference in 1972 considerably influenced Bulgarian scientists and the public, making them appreciate the European dimensions of the problem. As a result, researchers nowadays use several different models (of Bulgarian and foreign origin) to compute transboundary pollution and especially the import–export balance with each European country. Under certain meteorological conditions, transboundary transport of pollutants may account for some 50% of the total.

The major sources of air pollution, however, are local. For example, approximately 50 million hectares of the most productive soils around large nonferrous smelters are completely polluted by heavy metals. The accumulated lead (Pb), zinc (Zn), cadmium (Cd), and other metals are taken up by vegetation and animals and end up in food products. According to Ellen Silbergeld, a toxicologist with the Environmental Defense Fund, if children in the industrial town of Kuklen lived in the United States, they would be rushed to a hospital for detoxification because they have so much lead in their blood.

8.2 Solid Waste

Although the safe disposal of waste is not a national issue in Bulgaria, it is well recognized by the municipal authorities. So far, landfills are the only solution to solid wastes in the country, although their technical level is far from satisfactory. They present a constant threat to the

Table 8.3. Quantity of solid wastes in Bulgaria according to population of city.

Population size	1985			1990		
	m^3/pers.	t/pers.	t/m^3	m^3/pers.	t/pers.	t/m^3
(1) ~1,000,000 (Sofia only)	1.45	0.287	0.198	1.72	0.318	0.185
(2) 180,000–500,000	1.27	0.277	0.218	1.50	0.306	0.204
(3) 100,000–150,000	1.11	0.269	0.242	1.18	0.281	0.238
(4) 50,000–100,000	1.00	0.250	0.260	1.08	0.265	0.245

Table 8.4. Amount of solid wastes produced in various Bulgarian cities, in tons per year.

City	Population size[a]	1985	1990	1995[b]
Sofia	1	319,900	362,000	402,000
Plovdiv	2	94,800	111,100	127,600
Varna	2	83,700	97,900	111,600
Ruse	2	50,900	58,600	66,500
Burgas	2	50,600	58,100	66,800
St. Zagora	2	41,800	48,300	55,100
Pleven	3	35,200	38,600	42,900
Tolbukhin	3	29,300	32,200	35,800
Sliven	3	27,500	31,100	35,300
Shumen	3	26,900	29,600	33,100
Pernik	4	23,700	25,700	27,900
Iambol	4	22,500	25,200	28,000
Haskovo	4	21,900	24,900	27,700
Gabrovo	4	20,400	21,900	22,900
Pazardjik	4	19,400	22,000	24,800
Vratca	4	18,900	20,700	22,600
V. Tarnovo	4	17,400	19,200	21,800
Blagoevgrad	4	16,200	20,100	23,500
Vidin	4	15,700	17,000	18,500
Kardjali	4	13,800	16,200	18,600
Kustendil	4	13,500	15,200	16,500
Silistra	4	13,400	15,300	17,200
Mihailovgrad	4	13,100	16,000	18,000

[a]As defined in *Table 8.3.*
[b]Forecast.

Table 8.5. Capacities of planned incinerators.

Town	Tons per hour	Town	Tons per hour
Sofia	2 units × 15	Pleven	2 units × 5
Varna	2 units × 10	Ruse	2 units × 5
Plovdiv	2 units × 10	St. Zagora	2 units × 5
Burgas	2 units × 5	Tolbukhin	2 units × 5

environment. Considering the small area of arable land in the country, this practice cannot be accepted as a long-term policy.

Tables 8.3 and *8.4* give an idea of the growing solid-waste problem in 23 large Bulgarian cities. Quantities in *Table 8.4* should be increased by 35% to account for solid wastes from public buildings, municipal wastes, and wastes from enterprises. It should be noted that the caloric content of solid wastes varies from 1,130 kilocalories per kilogram to 1,580 kilocalories per kilogram, which is in the same range as lignite coal used in the thermal power stations. This was the major reason for planning new incinerators (*Table 8.5*).

In my opinion, the plan to build incinerators is overambitious and economically infeasible. From the environmental point of view, this plan has many shortcomings, having been developed by central authorities without proper consideration of differing regional conditions and technical alternatives.

Another important environmental problem is toxic waste. In Bulgaria there is no installation to treat this type of waste. The following data illustrate this point: solid wastes in Sofia contained toxic substances amounting to 168 tons per year in 1987, compared to 8 tons per year in 1979; daily flows of wastewaters containing cyanide and chromium compounds were 1,000 cubic meters per day in 1987 and 1,296 cubic meters per day in 1979. Concentrations range between 10 and 500 micrograms per liter for cyanide and 5 and 300 micrograms per liter for chromium.

8.3 Controlling Air Pollution

Among the highest priorities for environmental protection in Bulgaria is the development of a national strategy to cope with the ecological crisis that takes into account local and global environmental trends. The strategy should also account for the condition of Bulgaria's natural resources, and should include steps for the preservation of the environment (including air-pollution abatement) currently taken in more advanced countries. Such a strategy should follow as closely as possible the regional environmental strategy of the Economic Commission for Europe and the experience of European countries in the spirit of *Our Common Future*, the report of the Brundtland Commission.

The transition toward sustainable development is a long-term imperative facing every country and humanity as a whole. This means setting ecological goals for the immediate and long-term future. Requirements and criteria should match economic and social conditions. In some regions and during certain periods ecological goals should become major considerations.

Instead of imperfect centralized planning and economically inefficient use of enforcement methods, we should aim at developing balanced administrative measures valid for all forms of private or public ownership. We also need immediate economic measures. Steps for the realization of short-term and long-term ecological goals are an essential element of national policy during the transition to a market economy.

The way out of the ecological crisis is directly linked to a national strategy for nature conservation and regeneration, taking into account the territorial characteristics of various parts of the country. This calls for decentralized environmental management and should be part of the responsibilities of local authorities.

Restructuring the economy will be the main task in the coming years, and our future will be determined by fundamental decisions made concerning aging and obsolete industries and the total mismatch of raw material, energy supplies, and natural conditions. We believe that the selection of technologies for a new, restructured economy should be based on ecologically sound criteria, with sustainable development as a main priority. Scientific and technical experience should be adapted to Bulgarian conditions as far as possible.

The current government envisages a general packet of new legislation ensuring transition toward a market economy and new environmental laws fundamental to all activities related to the environment. It should include the best elements of nature-conservation legislation in Europe and elsewhere as well as international principles and standards.

The financing of environmental protection should be radically changed. Pollution costs should be internal and transferred to each industrial unit (that is, the *polluter pays* principle should become a general principle). The public as a whole should not foot the pollution bill. Fiscal practices of the USA and the ECE, such as taxation of toxic emissions, market incentives for lower emissions, and ecological action packages, should be seriously considered.

The second area of priority concerns technical and scientific options. For air-pollution abatement, the National Programme for Urgent Environmental Measures envisages the installation of electrical filters in the biggest dust polluters, closing or moving of dangerous plants from densely populated areas, use of less-polluting fuels and unleaded gasoline for transport, central and district heating in the big towns, construction of purification facilities for hazardous chemicals, introduction of low- or non-waste technologies, closed water cycles, and other actions. It should be pointed out that this program has been devised under strong public pressure and is meant to deal with an intolerable situation. The implementation of this program is doubtful or impossible under current economic conditions.

A viable system of monitoring and control is an absolute prerequisite for coping with the ecological crisis and managing the environment with public support. The implementation of such a system requires modern technical facilities and new standards for permissible concentrations of environmental pollutants in line with those of the ECE. Emissions control, monitoring, and standard-setting are inseparable parts of the monitoring system.

The solution to Bulgaria's ecological problems will be dangerously delayed or impossible to implement without foreign advice and aid.

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Chapter 9

Environmental Problems in the CSFR: Solutions through International Cooperation

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9.1 The Environmental Situation

The environmental situation has deteriorated in nearly all parts of the Czech-Slovak Federal Republic (CSFR) during the last decades, reaching critical proportions in some regions. Large areas of the Czech Republic (61% of the area containing 66.7% of the inhabitants of the Czech-Slovak Republic) have deteriorated (*Figure 9.1*). The situation is particularly critical in the coal-mining regions of northern Bohemia, the industrial region of northern Moravia, Ostrava, Prague and its surroundings, as well as in some other industrial regions of the country (Pilsen, Brno,

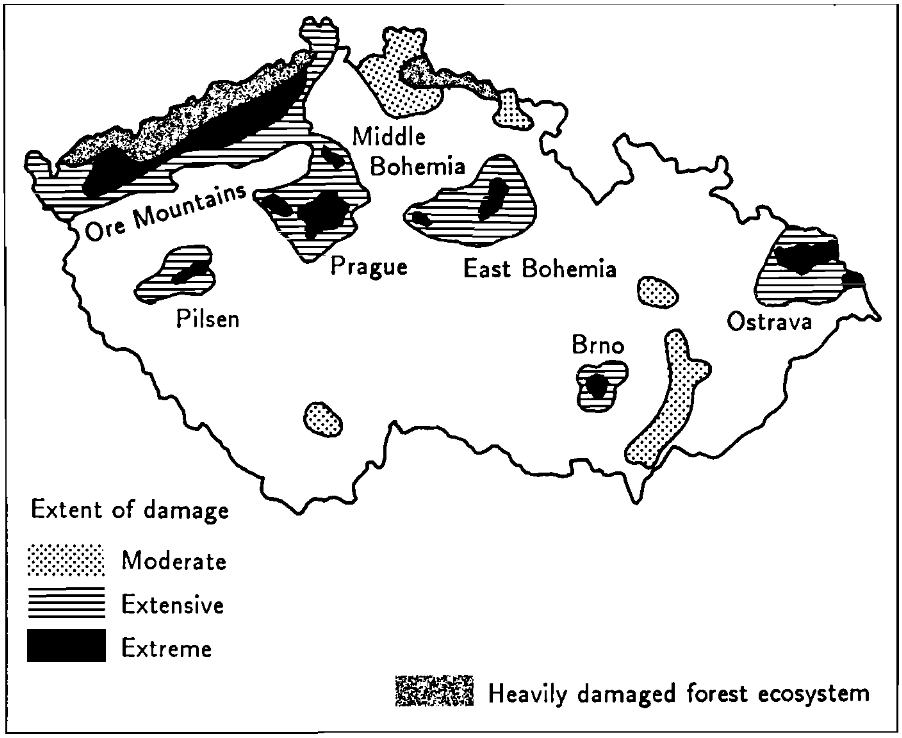

Figure 9.1. Regions with ecological problems in the Czech Republic.

Hradec Králové-Pardubice). Some regions of the Slovak Republic have been environmentally devastated by local industries (*Figure 9.2*).

Nearly 6 million Czechs (57% of the republic's population) live in an extremely degraded environment representing more than 7% of the territory of the Czech Republic. All fundamental environmental components suffer varying degrees of damage over an area of 80% of its territory.

The problems of air pollution as well as ground- and surface-waters contamination are well known. In addition, gradual soil degradation, decreasing vitality of forests, increasing destruction of trees, and impairment of the landscape's ecological balance lead to a gradual extinction of many plant and animal species. Hazardous substances accumulate in the environment thereby endangering the ecological adaptability of ecosystems. Health conditions among the population are seriously threatened,

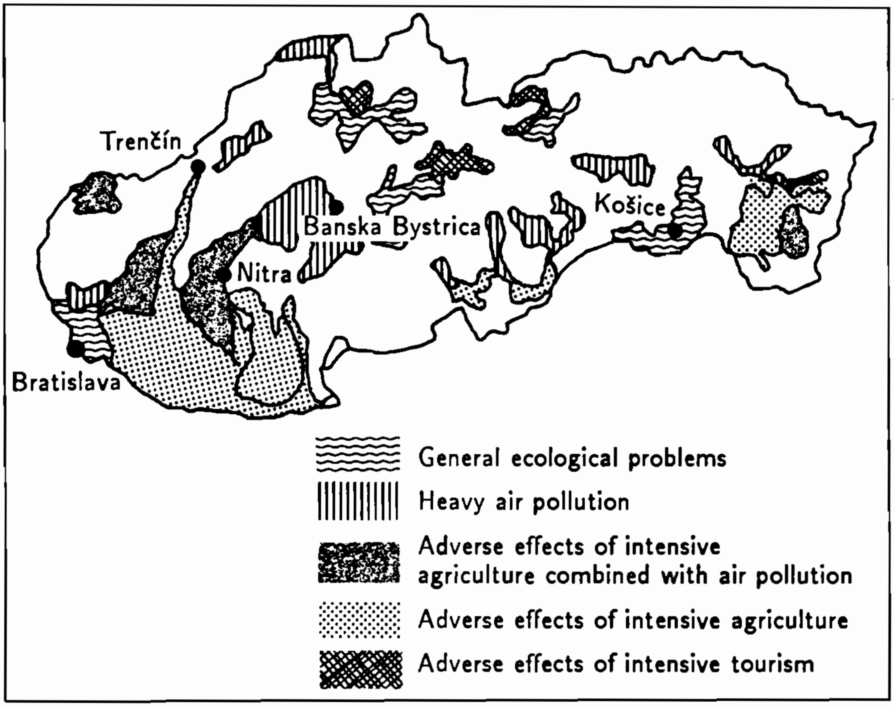

Figure 9.2. Regions with ecological problems in the Slovak Republic.

and average life expectancy in the Czech Republic is five to seven years shorter than in the developed industrial countries (*Figure 9.3* and *9.4*). The infant mortality rate in the CSFR is 14.5 per 1,000 live births compared with 9.1 per 1,000 in EC countries.

Economic damage and losses brought about by the impaired environment are on the increase and estimated to cost some Kčs20 billion, which is at least 7% of the national income.

The CSFR also contributes significantly to environmental pollution in other countries, exporting more harmful matter than it imports. *Table 9.1* shows transboundary transport of SO_2 to neighboring countries. The distribution of emissions per square kilometer is given in *Figures 9.5* to *9.7*. Despite all efforts, CSFR's commitment to reduce SO_2 emissions by 30% before 1993 will probably not be fulfilled.

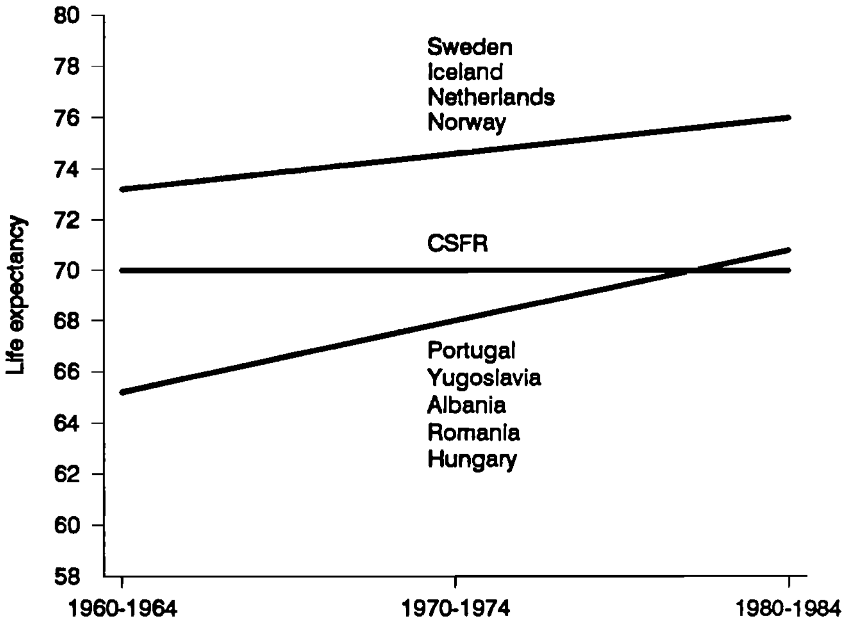

Figure 9.3. Average life expectancy at birth, 1960 to 1984, in selected European countries.

9.1.1 Air pollution

Air pollution is one of the biggest environmental problems in the CSFR, especially in the Czech Republic. At 3,150 kilotons in 1985 (203 kilograms per person per year), SO_2 emissions in the Czech Republic are among the highest in Europe – 2.48 times higher than in Western Europe per unit of GNP. In northern Bohemia, SO_2 air concentrations are approximately 20 times the national average (in the vicinity of Chomutov-Hřensko it is 100 to 140 micrograms per cubic meter as compared with the international norm of 60 micrograms per cubic meter). In this area, maximum limits are exceeded 128 days a year; peaks of 3,000 micrograms per cubic meter occur under inversion weather conditions. About 52% of SO_2 emissions come from brown-coal-fired power stations, 20% from industrial plants, 7% from local heating systems, and 3% from transport. The high level of SO_2 pollution is due to the use of brown coal (the main energy source), whose sulfur content averages about 1.2%

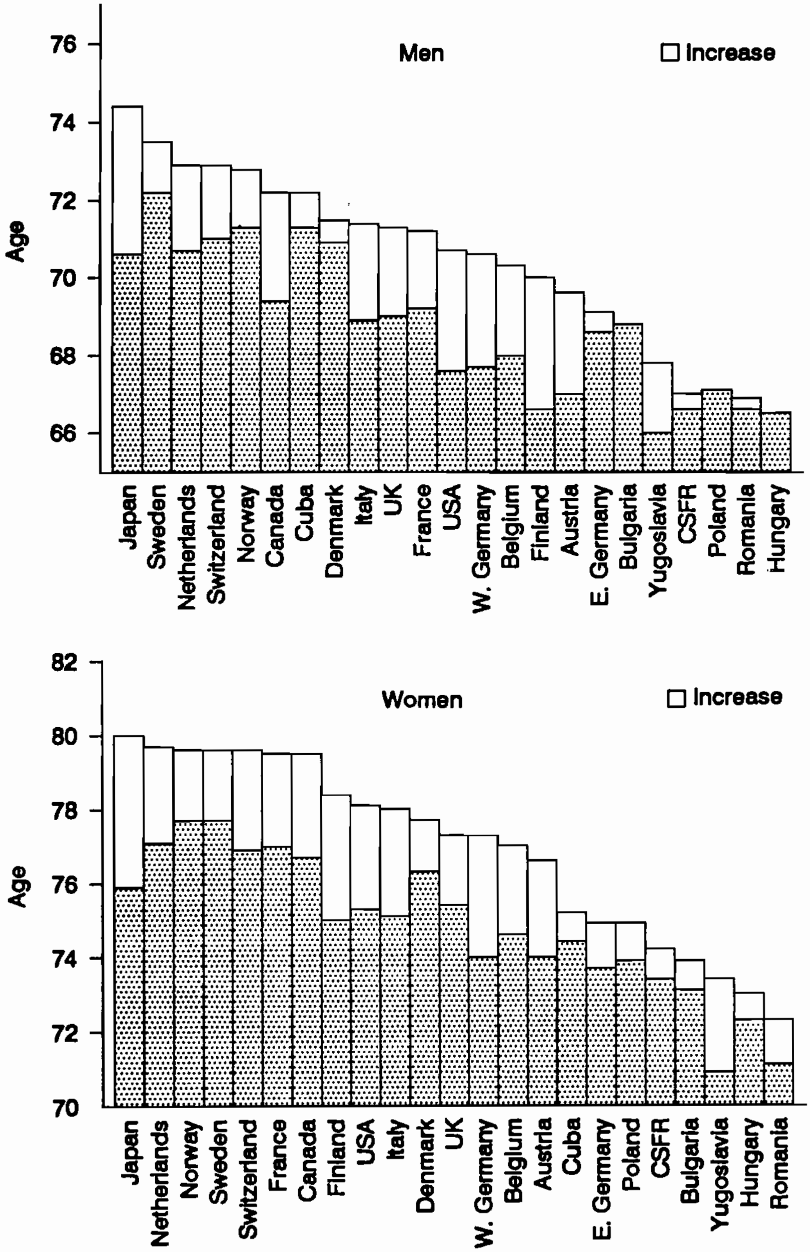

Figure 9.4. Average life expectancy at birth in selected countries. Data from 1970 to 1974 compared with data from 1980 to 1984.

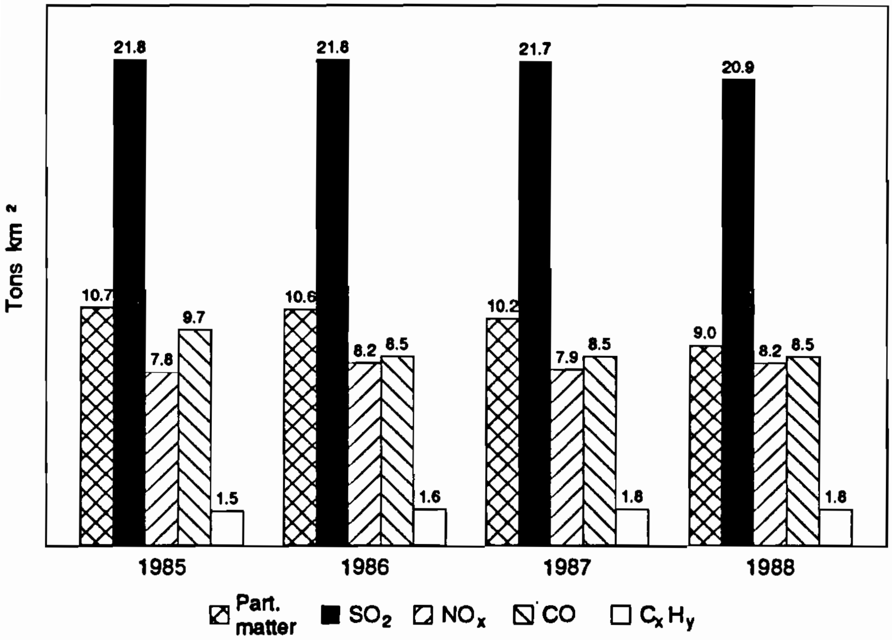

Figure 9.5. Emissions per square kilometer of major air pollutants in the CSFR.

to 3.5%, but which in some places exceeds 15%. Recently, the caloric value of brown coal has fallen and its ash and sulfur content has risen.

There are four large coal-fired power stations in north Bohemia with a capacity of more than 1,000 MW (Prunéřov 1,700 MW; Tušimice 1,400 MW; Počerady 1,200 MW; Mělník 1,250 MW). Until now no desulfurization units have been installed in these power stations except for one in the Tušimice complex, which uses the magnesium method without success.

Air quality is also bad in the towns where pollution from local heating systems and old vehicles is very high. Air quality has deteriorated particularly in industrial areas and places with high population density, namely, Prague, the north Bohemian region, Bratislava, and the Ostrava-Karviná industrial conurbation. This is evidenced by the average annual and peak concentrations of nitrogen oxides, ozone, hydrocarbons (including chlorinated hydrocarbons), carbon monoxide, and fly

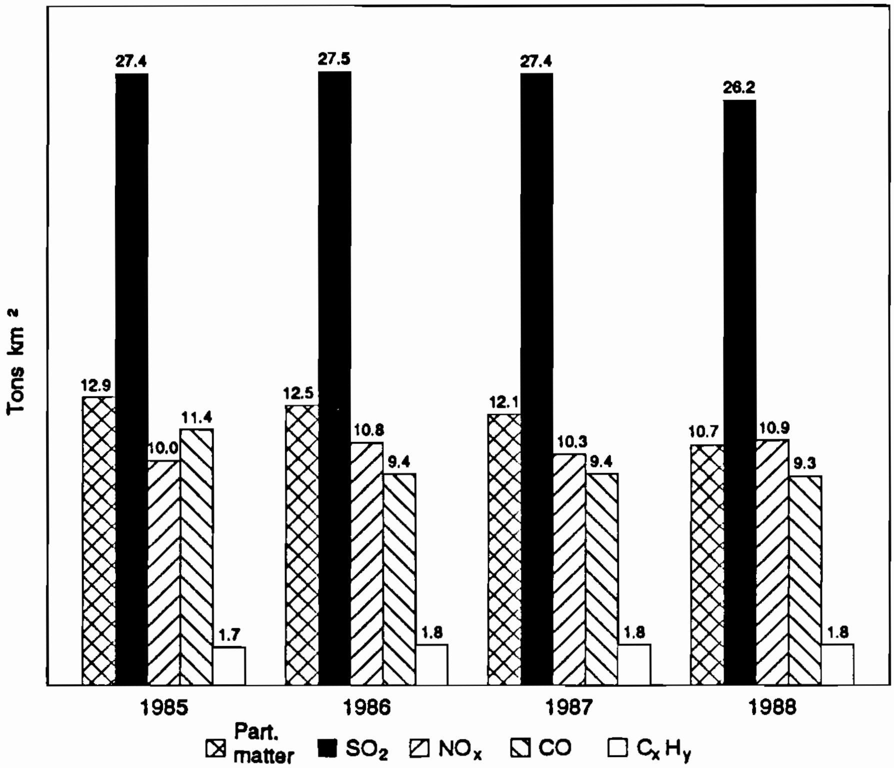

Figure 9.6. Emissions per square kilometer of major air pollutants in the Czech Republic.

ash, which contains asbestos, lead, mercury, cadmium, arsenic, vanadium, and radioactive elements.

The total quantity of nitrogen oxide emissions is estimated to be about 1,200 kilotons annually, which amounts to 57 kilograms per capita (converted to NO_2). In the European context this means that the CSFR unfortunately places first in NO_2 emissions. These emissions are caused primarily by energy and industry (71%), transport (22%), and central as well as local heating systems (7%). The relatively low NO_x emissions from power plants are due to the large dimensions of the combustion chambers and the low temperatures at which brown coal is burnt.

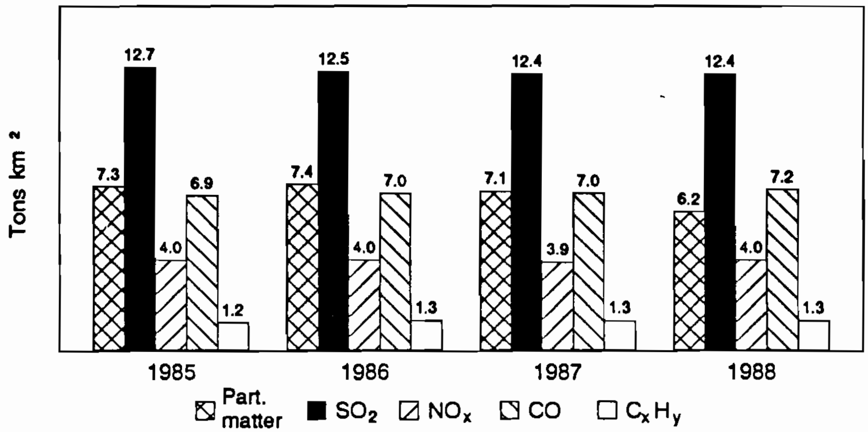

Figure 9.7. Emissions per square kilometer of major air pollutants in the Slovak Republic.

Significant emissions come from the chemical industry and contain various hydrocarbons, halogen compounds, and so on. Municipal waste-incineration stations in Bratislava and other towns are not equipped with efficient filters and gas scrubbers. Incineration of plastics in municipal waste is responsible for the emission of hazardous organic substances, including dioxins. The CSFR, with its production of chlorinated fluorocarbons (about 7,000 tons in 1988), contributes to the destruction of the ozone layer. The CSFR emits about 60.4 million tons of CO_2 each year, which is equivalent to 4.1 tons per capita (converted to C). In addition, air pollution from accidents and large fires is a great local hazard. In 1988, for instance, several thousand tons of chemicals accidentally ignited in a poorly secured storehouse for fertilizers and other agrochemicals at Boršov in southern Moravia.

Emissions of solid materials, particularly fly ash, and suspended particles increased from 0.8 million tons in 1950 to 2.8 million tons in 1985 and continue to grow gradually due to the deterioration of electrostatic separators installed 15 to 20 years ago.

The territory of the Slovak Republic is relatively less afflicted by air pollution than the Czech Republic. Nevertheless, high concentrations of harmful substances are observed particularly in river valleys and basins where a considerable part of the population lives. Air is polluted by hazardous chemicals released by industrial enterprises in several regions. For instance, the vicinity of Žiar nad Hronom is contaminated with fluorine compounds from the local aluminum works, and the area around Bratislava is contaminated by the chemical industry.

Besides high concentrations of harmful substances in the atmosphere, of particular importance to living organisms are peak concentrations lasting for several minutes, hours, or even days from industrial accidents or unfavorable meteorological conditions.

In the CSFR, air emissions are rarely measured directly. Most estimates are based on balance calculations. Monitoring systems have been installed only in Prague, north Bohemia, Ostrava, and Bratislava. Emergency procedures to protect the population are followed during unfavorable weather conditions. In general, the monitoring network has to be modernized and broadened to include other regions and towns.

Sources located in other states play a considerable role in the transboundary transfer of emissions (*Table 9.1*). Particularly significant are the contributions from Poland and the former East Germany. They have a very harmful impact on the border forests of Bohemia and Moravia. In the Giant Mountains, for instance, about 52% of the total burden caused by sulfur deposits comes from these two countries.

However, the CSFR is also a significant exporter of atmospheric pollutants. Overall, sulfur exports are approximately 20% to 60% higher than imports (*Table 9.1*). These data vary from year to year and are influenced by the measurement methods used. In view of the rapid reduction of sulfur emissions in Western Europe, the CSFR active balance is very likely to increase.

9.1.2 Water pollution

Since the mid-1970s, there has been an increase in water pollution in the form of organic matter, insoluble substances, oils, fertilizers, and pesticide residues. The main water polluters are agriculture (50% of water pollution), industry (high levels of pollution caused by the chemical- and food-processing industries), and human settlements (many towns and villages, including newly built settlements, have no water-treatment plants; even Prague and Bratislava do not have sufficient water-treatment capacity). Only about 40% of the wastewaters in CSFR receive adequate treatment (*Table 9.2*). Sludge from purifying

Table 9.1. Sulfur dioxide emissions and deposition in selected European countries in 1982, in thousand tons per year.

	Receivers							Total	Emissions
Emitters	Aut.	CSFR	W.Ger.	E.Ger.	Hun.	Pol.	USSR	emissions	exported
Austria	151	64	23	–	25	20	41	430	279
CSFR	92	1,266	126	146	120	356	496	3,370	2,104
West Germany	56	223	1,160	176	27	165	393	2,510	2,350
East Germany	54	438	265	1,117	40	478	636	4,023	2,883
Hungary	33	157	14	10	448	99	367	1,720	1,272
Poland	23	170	32	41	37	1,012	691	2,500	1,488
USSR	–	89	18	18	24	215	22,674	25,500	2,826
Total imported	690	2,999	2,474	1,720	923	2,825	27,553		
Receipt from abroad	539	1,733	1,314	603	475	1,813	4,879		

Source: Highton and Chadwick, 1982.

plants in many places qualifies as hazardous waste as a result of contamination by heavy metals, mainly cadmium.

Runoff of manure and fertilizers, as well as pesticides from agricultural soils and erosion, causes approximately 50% of the water contamination; its influence has increased by about 25% during the last 15 years. Ground and surface waters are contaminated by heavy metals in wastewater from towns and villages, and from leakage of poorly secured dumps of solid and liquid wastes, including a wide range of hazardous wastes. Additionally, atmospheric deposition of harmful substances produce acidification of surface waters. If current trends continue, about 50% of the water flows will have unacceptable nitrate content by the year 2000.

The CSFR suffers from a shortage of water, and the demand for drinking and supply waters is unreasonably high. Water demand in the Czech Republic increased by 47% between 1960 and 1985, with groundwater demand increasing approximately fivefold during the last 40 years. Developments in the Slovak Republic were similar. From 1960 to 1985, for instance, in Prague the demand for drinking water increased from 230 liters to 533 liters per capita per day and in Bratislava it increased to 500 liters, while in Vienna demand dropped to 270 liters.

There is a considerable increase in contamination of groundwater by nitrates, pesticides, fertilizer residues, and other substances, including chlorinated hydrocarbons. During the last 30 years, average nitrate content of groundwater increased fourfold from 30 to 120 milligrams per liter and in agricultural areas from 24 to 56 milligrams per liter.

The quality of drinking water represents a crucial problem. Approximately 50% of water samples do not conform to the standards of the CSFR. These standards are themselves outdated because they neglect some important measures of water quality. In many places, water supplies are unfit for drinking, and local authorities prescribe mineral water or bottled water for children.

As most Czech and Slovak streams and rivers (with the exception of the Danube) originate in the country and flow to neighboring countries, their pollution is also a serious international problem. An international agreement to clean the river basin of the Elbe River was adopted in 1990, and it is expected that international cooperation will solve this problem.

Table 9.2. Wastewater treatment in the CSFR, in million cubic meters.

	Discharged wastewaters				Wastewaters discharged into public sewage (including stormwater)					
								Treated wastewaters		
Year	Total	Conditionally pure wastewaters	Untreated wastewaters	Treated wastewaters	Total	Conditionally pure wastewaters	Untreated wastewaters	Total	Mechanical purification	Biological purification
CSFR										
1986	4,641	1,217	1,609	1,815	1,704	72	321	1,311	202	1,109
1987	4,673	1,138	1,706	1,829	1,776	102	332	1,342	178	1,164
1988	4,616	1,116	1,651	1,849	1,766	73	316	1,377	175	1,202
Czech Republic										
1986	3,008	848	985	1,175	1,107	20	233	854	92	762
1987	3,011	747	1,129	1,135	1,158	28	242	888	92	796
1988	2,970	748	1,007	1,215	1,161	24	255	882	113	769
Slovak Republic										
1986	1,633	369	624	640	597	52	88	457	110	347
1987	1,662	391	577	694	618	74	90	454	86	368
1988	1,646	368	644	634	605	49	61	495	62	433

9.1.3 Other environmental problems

Another important ecological problem is the instability of soils due to large-scale agriculture that ignores the character of the landscape. About 54% of agricultural land is endangered by erosion; large fields have lost their ecological stability.

Forests have deteriorated rapidly. In 1986, 57% and 15.6% of the total forested area was damaged in the Czech and Slovak republics, respectively. The situation is particularly catastrophic in the Giant Mountains National Park where the forests have been completely destroyed due to deposition of atmospheric pollutants in the last 15 years.

Extensive exploitation of mineral resources destroys the landscape. The mining of brown coal increased to 100 million tons; the mining of hard coal, to 28 million tons.

Harmful substances released into the environment by human activity contaminate the food chain and later contaminate consumers who are the last links in the chain. This endangers the health of the population and reduces life expectancies.

All these influences result in stress and deterioration of the biosphere, disturbance in ecological balance, and loss to the aesthetic value of the landscape. Last but not least, it has consequences for the quality of life and the moral and economic development of society.

9.2 Today's Situation

The most significant causes of the environmental problems in the CSFR are similar to those in all former socialist countries:

- Excessive exploitation of natural sources, disregarding enormous waste emissions of all kinds (solid, gaseous, and liquid wastes, including thermal waste).
- Economies based on high-energy and demand for raw materials, industries equipped with outdated technologies, and a bias toward metallurgy or production of machine tools.
- Agriculture oriented to large-scale production, ignoring natural conditions in the country.
- A command economy with insufficient economic tools for environmental and ecological protection measures. This has led to wasteful

manufacturing technologies, which deplete natural resources and destroyed the environment.

Secrecy and inadequate information played a significant role in this respect; the public did not have democratic opportunities to protest against further degradation of the environment. Institutional management of environmental care was insufficient and restricted to formalities. Various departments and ministries were simultaneously responsible for the management and checking of all components of the environment and for the manufacturing sector.

Similarly, resources allocated to environmental protection and damage repair were inadequate, especially in the late 1970s and early 1980s. They decreased in absolute terms as well as relative to total expenditure. Resources were inadequate considering the importance and scope of the problems and were sufficient to repair the most serious impacts, but not enough to prevent damage.

9.3 Starting Points

CSFR authorities are now dealing with the unhealthy legacy of the past regime. They must contend with the following:

- A ruined, low-efficiency economy with high-energy and raw-material demand, and one which is dependent on imports for these resources.
- Low-quality primary energy sources, above all brown coal with high sulfur content. This is the main energy source, despite the newly constructed nuclear power stations. These new stations should reduce emissions, maintain the volume of electricity generated, and be the basis for a transition to a higher level of manufacturing technologies. However, the nuclear plants themselves use outdated technologies.
- Low levels of production with outdated machinery and thus ineffective utilization of inputs.
- A high proportion of heavy industry, including metallurgy, machine tools, and armaments, the structure of which has to be updated and converted to high-technology peacetime production.

- Subjective and unreal prices for both production and consumption, lacking any import or export links to world markets; in addition, an inconvertible currency and deformed or nonexistent market relations.
- Unreal prices of natural resources and a low level of technology leading to waste of all kinds and thus low efficiency of utilization of raw materials and energy.
- A ruined market with large state monopolies and practically no private sector in industrial production, agriculture, and services.
- Low efficiency in exporting products to world markets; thus low prices per kilogram and low hard-currency incomes.
- A critically loaded environment; devastated air and ground and surface waters, dying forests, and impaired ecological balance.
- Subjective decision making, generally low level of environmental investments, high costs, and limited funds for solving problems, which mean enormous costs in the future to remedy the damages.
- Tremendous economic losses resulting from the damaged environment, only a small part of which can be quantified or compensated for because of nontransparent economic relations and prices.
- Pollution carried down the food chain leading to an unhealthy lifestyle and thus to a great increase in present and future health-care costs. However, health care itself is badly organized and of poor quality and has not been able to reduce the high mortality rates in the country.

9.4 Principles of a Solution

Many of the tremendous problems faced by officials in the CSFR, and society, must be tackled simultaneously, namely:

- Changing the structure of the entire economy, its manufacturing and service sectors, to increase efficiency and raise technology levels to reduce material and energy demands and to limit waste. This means the introduction of real prices for inputs, prices that reflect scarcity or environmental costs of goods.
- Introducing self-regulating markets by breaking the monopoly of state enterprises and making them private, as well as by freeing prices.

- Obtaining advanced technologies by increasing the technological quality of products and import efficiency, or by utilizing foreign assistance through capital infusions and joint ventures.
- Keeping the economy working, without serious failures, to provide sufficient raw materials and energy, which is very difficult at present due to the high dependence on imports. It is also necessary to find a real and ecologically sustainable energy strategy to generate electricity in the near future (nuclear energy, desulfurization, import, and so on) bearing in mind the need to use only ecologically benign technologies.
- Avoiding serious social problems due to rapid unemployment, while closing down inefficient plants, retraining employees, and transferring them to essential services.
- Solving all accumulated environmental problems, especially polluted air and waters, soil erosion, and endangered ecological balance.

In addition, plans must be developed to stop the worsening of these problems and their influence upon the health of the population and to improve health care. There are great social, political, economic, and ecological hazards associated with these tasks, and they must to be tackled simultaneously. Several very unpopular measures will have to be taken to achieve this.

9.5 CSFR's Advantages in this Situation

As compared with the majority of other liberated countries with former centrally planned economies, the CSFR has certain advantages to coping with this crisis:

- A long history of democratic and social traditions. It has been an industrially advanced country for more than 200 years. It has a highly qualified and comparatively cheap labor force combined with a high degree of adaptability to production change and the ability to improvise under unexpected circumstances.
- A relatively low standard of living, with consumption habits constrained by shortages, in comparison with more advanced industrial countries. Therefore, even a small improvement of the current situation will bring considerable political and social benefits.

- Relatively low debts to Western countries as well as a low level of outstanding credit to other countries. The breakup of the Council for Mutual Economic Assistance and the country's transition to a convertible currency has caused problems with supplies of some raw materials and products as well as with exporting CSFR's products.
- Relatively high manufacturing capacity, despite inefficient production. Machine and armament manufacturing could be converted quickly to useful and efficient industries using up-to-date technologies (such as the manufacture of equipment for environmental protection and measuring devices).
- Relatively high overemployment in the manufacturing sector can provide a manpower reserve for the services and labor market, although reducing employment in manufacturing can cause social problems.
- A boom in revelations about the economic and ecological situation and the state of society, which has caused a great shock to the people. However, there is room for hope that people will understand that these problems accumulated in the past and that their solutions will at first be very difficult, expensive, and painful.

Because of these factors, the CSFR has a chance to get out of its present situation relatively quickly. The social and political problems that may arise can be coped with, especially with the assistance of more advanced industrial countries.

9.6 Economic Reform and Conditions for Solving Environmental Problems

The economic reform schedule was elaborated after long discussions and submitted by the government in early September 1990 to the federal assembly. The federal government authorized the State Ecological Policy. This policy consists of formulation of the problem, goals of environmental control, principles of environmental control, and strategies of environmental control. The appendix to the document presents methods and basic principles of how to put this policy into practice as well as a list of priorities based on the concept of sustainable development. The government welcomes international multilateral or bilateral cooperation in the preparation and implementation of the projects.

The priorities are divided into the following programs:

- *Programs of the Environmental Care System* which specialize in legislative, organizational, and economic tools and other methods to evaluate the effects of investments on the environment, ecological quality of products, environmental information, and structural changes in the economy.
- *Programs of Solving Specific Environmental Problems* which include waste reduction and recovery; reduction of atmospheric emissions; ecological control of water management; forestry, soil protection, and nature conservation; and restoration of the ecological balance of the landscape.
- *Sectorial Ecological Programs* which deal with the environmental impact of energy generation; environmentally sound management of agriculture, chemical, textile, rubber, metallurgy, and machine and building industries; improvement of the environment in settlements; and improvement of housing and environmentally benign transportation systems.
- *Programs of Information Dissemination, Environmental Education, and Support of Civic Activities.*
- *Programs of Research and Technology Related to Environment* which try to solve problems of nature–society relations, above all damage correction, development of environmentally safe technologies in production and consumption, monitoring of environmental pollution, and development of the educational system and decision-making system at all levels.

These priorities for solving environmental issues in the CSFR are regarded as an open agenda that can and should be extended and completed. The State Ecological Policy was submitted to an expert committee consisting of more than 80 leading experts attached to the federal committee of the environment.

9.7 Solutions through International Cooperation

In the period of transition from central planning to a market economy it is necessary to introduce and encourage mechanisms that break up market monopolies. This means the privatization of state, cooperative, municipal, and other enterprises and their transformation into effective well-managed firms with the active participation of owners and managers. The federal government and the government of each republic have prepared laws that allow an inflow of foreign capital to provide ready assistance to the economy and, at the same time, create lawful guarantees for foreign investors and joint ventures.

Simultaneously, it is imperative to prevent further deterioration of the environment during this process of privatization and the introduction of new technologies. No firms will be allowed to introduce unfavorable technologies or import products into the CSFR that violate the regulations valid in their own countries. New regulations and standards in the CSFR will have to meet European Community conditions and standards. Basically, any cooperation has to aim at reducing the demands of the economy on energy and raw materials, at updating its manufacturing equipment, at employing qualified people, at utilizing all production capacities, and at reducing the environmental load.

In addition to the projects contained in the State Ecological Policy and the forms of cooperation and assistance included in them, three projects should be mentioned that could be important in environmental protection, not only for the CSFR but also for wide international cooperation, namely:

- The so-called Dienstbier Marshall-Plan, which was put forward by Foreign Minister Jiri Dienstbier in a speech at Harvard University. Unfortunately, this plan has not been discussed in detail in foreign forums. It envisages assistance to the East European countries in the form of a loan to the former Soviet Republics of about US$12 billion on condition that it be used only to purchase products from East European countries. These countries produce goods that cannot be marketed in more advanced industrial countries, but the closure of the plants in these countries would result in serious social disorder in the newly established democracies of these countries. High unemployment in particular could seriously endanger the quick transition to an efficient economy. The money paid for supplies produced in Eastern Europe would be used to purchase up-to-date technologies from advanced industrial countries, thus solving the problem of a rapid transition from a centrally planned economy to a market economy. At the same time, the project would establish a market for industrial countries to sell these technologies.

- The Eco-Marshall Plan, proposed by the Deutsche Institut für Wirtschaftsforschung (DIW), deals with the environment in Central and Eastern Europe. The plan recognizes that the environmental problems of these countries influence all of Europe and the whole world, and cannot be solved with capital from these states alone. These tasks are assumed to require approximately US$200 billion by the year 2010 for the former GDR, the CSFR, Poland, Hungary, and the former USSR republics. The DIW plan calls for "help for self-help" (Hilfe für Selbsthilfe). In western countries, the environmental load resulting from transboundary air pollution and pollution of water courses would decrease. Western economies would also benefit, because these credits would be used to purchase modern technologies from them (Wicke and Hucke, 1989).
- The establishment of an International Institute for Environmental Studies (IIES), with a structure similar to IIASA's. This institute could reside in the newly reconstructed castle of Jezeri in the north Bohemian brown-coal region. Leading experts from various member states could work directly on pressing environmental problems in a model region whose damage is unlike any other in the world. This research would also help to solve problems in other countries.

9.8 Conclusion

It is clear that solutions to environmental problems in the CSFR and other East European countries have to be found in concert with solutions to economic problems, with the cooperation and assistance of advanced industrial countries. The basis for these solutions is an ordered process of introducing democracy without social or political shocks, but with a rapid transition to a market economy. The strengthening of confidence and cooperation in Europe represents a basis for cutting down defense costs and using the savings primarily for coping with environmental problems. These are key issues for sustainable development not only in Europe but also worldwide.

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Chapter 10

Water-Quality Management in Hungary: Past Experiences and Future Needs

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Characteristic of the centrally planned economy of Hungary was the extensive consumption of raw materials and energy and the lack of proper environmental policy instruments and decision analyses. These factors led to serious environmental problems. Although technical elements of water-quality management are well developed, major changes are still needed.

This chapter reviews the present situation of water availability, pollutant loads, and the quality of receiving waters in Hungary. Two special problems are addressed, namely, the eutrophication management of Lake

This chapter is based on information compiled before mid-1991. Despite changes since then it contains valuable data about this part of the world.

Balaton and the issue of the Gabčikovo-Nagymaros River dam complex. Future needs and priorities are also discussed.

10.1 The State of Water Quality

10.1.1 Water availability

Some 94% of the surface water in Hungary during an average August (with an 80% probability) originates from abroad. This fact gives Hungary a special downstream character. Groundwater resources primarily comprise waters that are stored in the banks of rivers (three-quarters of this storage is located in the alluvial terraces of the Danube River).

Between 1970 and 1985 water demand doubled (reaching 6 billion cubic meters per year) but a much lower rate of increase is expected up to the year 2000. The most significant water user is industry, followed by agricultural and municipal water demands. About half of the municipal demand is met by utilizing bank-filtered water resources.

The result obtained by comparing water demands with water resources is quite favorable; water demands will be satisfied even at the turn of the millennium. However, the fairly uneven spatial distribution of resources and demands should also be considered. Whereas the ratio of free water resources between the Danube and Tisza rivers (*Figure 10.1*) is 85:15, the ratio of the demand for water in their basins is 59:41. In periods of drought (such as the last eight years) this ratio shows an even more unfavorable picture in the basin of the Tisza River. To overcome the problems of resource distribution, a carefully designed regional water-management policy is needed. In addition to this, the downstream character of the country might result in a decrease of available water resources, mainly in the water system of the Tisza River, due to the construction and operation of reservoirs in the upstream countries.

10.1.2 Pollution loads

The quality of Hungary's ground and surface waters is directly determined by the extent of pollution both in Hungary and abroad. Water quality is indirectly affected by socioeconomic development, including advancement of industrial and agricultural technologies and the portion of GNP used for environmental management. Industry, being the

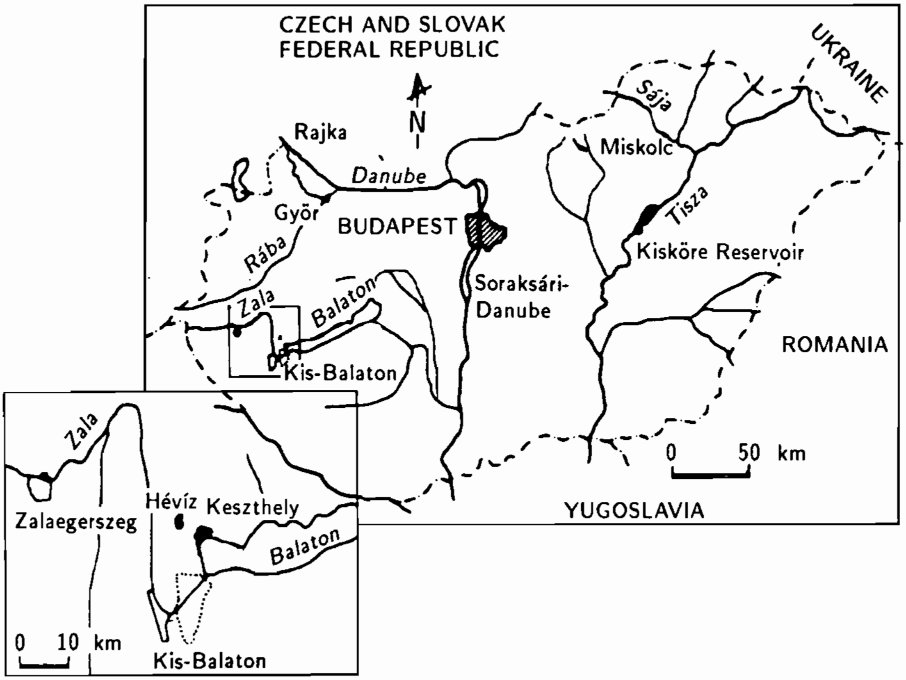

Figure 10.1. Map of Hungary showing key water courses.

largest water consumer, is also the largest polluter. Although the ratio of untreated wastewater discharges to the total discharge decreased from 40% to 27% between 1965 and 1985, the untreated discharge rate still amounts to 84 million cubic meters per year. Consequently, even today substantial pollution loads contain various organic substances, heavy metals, oils and oil products, and other contaminants. The effect of agricultural activities on water quality is mainly of a non-point-source character. A considerable quantity of liquid manure is generated, 20% of which is discharged into receiving water bodies; a solution to the disposal of these wastes has not yet been found.

During the past decades, municipal water supply has grown much faster than the rate of sewage collection and sewage treatment. In 1945, 22% of the population was connected to the water-supply system and 17% to the sewer system. Today, 85% of the total population is connected to the water-supply system, but only 47% is connected to the sewer system. Consequently, the municipal-pollution load has been steadily increasing and the current rate of untreated sewage discharge to ground and surface waters is about 10 billion cubic meters per year. The actual situation is even worse, since about two-thirds of the "treated effluent" has received only mechanical treatment (Hock and Somlyódy, 1990).

10.1.3 Water quality of surface water

Following a special survey in the 1950s, the regular monitoring of the quality of surface water on a national scale was started in the 1960s. The regular monitoring network consists of 250 sampling stations. Sampling frequency ranges between 12 per year and 52 per year. The frequency is weekly for 39 important rivers. A comparison of the system in Hungary to that in Austria, the CSFR, the Netherlands, and Bavaria has shown that both the spatial density and frequency is highest in Hungary (Somlyódy *et al.*, 1990).

The number of components varies from 11 to 90 depending on water-use classes, which include "biological stability," drinking-water supply, industrial use, irrigation, and fisheries. The number of routinely measured chemical parameters is about 25.

The standards and technical guidelines for evaluating the quality of surface water specify "desirable" and "acceptable" limit values, depending on the type of water use. Water-quality classes are organized as follows:

- The water quality is of class I if the upper limits of quality classes I and II are not exceeded by 80% and 95%, respectively, of all the measured values.
- The water quality is of class II if 80% of all measured values falls within the limits of classes I and II.
- The water quality is of class III if the conditions of class II are not met.

In the case of evaluating water quality on the basis of several components there is the option of omitting some of the components from the evaluation. For example, when analyzing for 25 components, 20%

Table 10.1. Long-term trends in water quality at the 48 most important river stations in Hungary (units: number of stations).

	COD	BOD-5	O_2	NH_4^+	NO_3^{2-}	PO_4^{3-}
Water-quality deterioration	18	15	29	21	38	34
Water-quality class II–III	30	32	15	32	9	39
Water-quality class II–III deteriorating more than 3% per year	4	1	0	12	5	23

Source: Hock, 1990.

of them (i.e., five) may fall into class II, while the composite quality can still remain in class I. On the basis of this evaluation, *Figure 10.2* illustrates the various water-quality classes in Hungary.

The two major drawbacks of this evaluation are that it is based on 80% duration values (which, in the case of an asymmetric distribution, can even be lower than the mean) and that it allows for the omission of certain components (Somlyódy *et al.*, 1990).

On the basis of regular observations, the quality of surface water and its changes can be evaluated. For example, the six observed components of oxygen and nutrients characterize the trophic state of the water as well as the process of nitrate enrichment. *Table 10.1* indicates the number of monitoring stations at which quality deterioration was observed from 1970 to 1989 (Hock, 1990).

A comparison of these results with those of the 1950 survey shows that the number of stations where the water quality is lower than class I has increased. Nevertheless, the rate of deterioration has slowed and even been reversed in some streams because of control measures. The changes that have occurred in the Danube during the past three decades are clearly illustrated by the trend of nitrate concentration (*Figure 10.3*).

The national average conditions can be supplemented by information about the changes in the past two decades in five major rivers: Kapos, Zala, Zagyva, Danube, and Tisza (*Figure 10.1*). Some water-quality data from these rivers are presented in *Table 10.2*. The drainage basins of the first three rivers are located entirely in Hungary (that is, Hungary is responsible for all of their pollution). The analysis of the water quality for the Danube and Tisza rivers can best be made by comparing the water qualities of inflowing and outflowing sections.

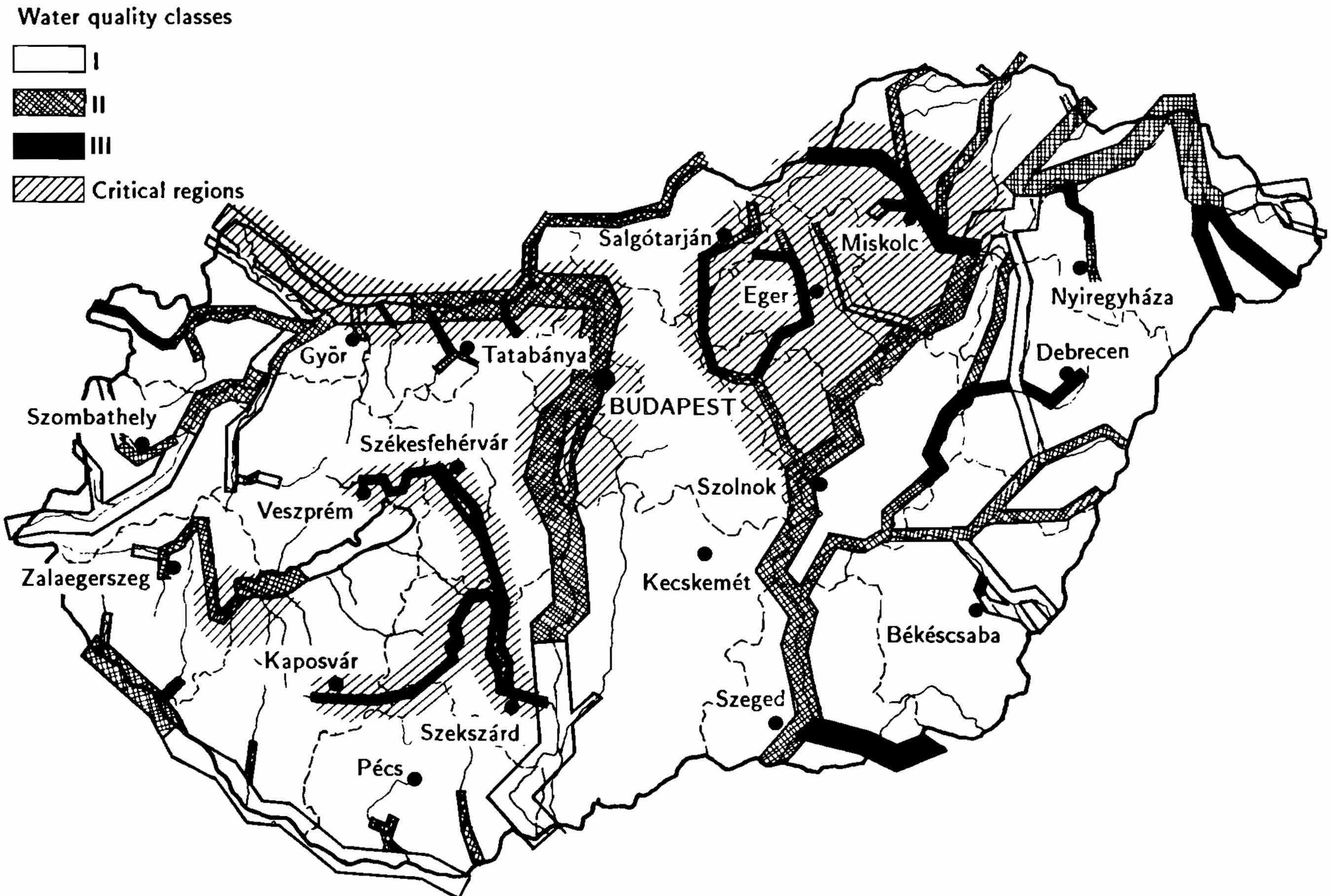

Figure 10.2. Quality of surface water in Hungary measured annually by the Institute of Water Management on the basis of standard specifications.

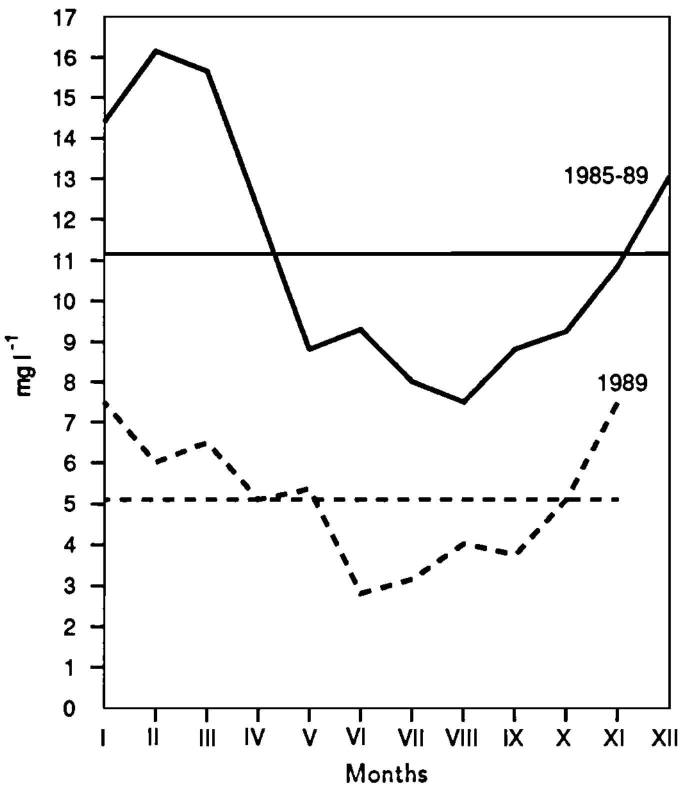

Figure 10.3. Annual variation of nitrate concentrations in the Danube upstream of Budapest, expressed as the monthly average values of 1959, in the period 1985–1989. Source: Somlyódy and Hock, 1991.

The Kapos, Zagyva, and Zala rivers have continuously deteriorating water quality, with the exception of their oxygen contents. The Danube entrance station has a class I water quality for traditional chemical components (pH, NO_3^{2-}, PO_4^{3-}, biological condition, chlorophyll-a class II, mineral oil class III) and has exhibited a slight improvement in quality, except for nitrate ions (see *Table 10.2*). The situation at the outflow station is similar. At the outflow station of the Tisza, the changes are consistently unfavorable for almost all components, while the situation at the entrance station is somewhat better (*Table 10.2*).

Table 10.2. Variations in time of nitrate and orthophosphate ions (in milligrams per liter) on the basis of five-year averages.

Water course	Nitrate ions 1970–1974	1975–1979	1980–1984	1985–1989	Orthophosphate ions 1970–1974	1975–1979	1980–1984	1985–1989
Kapos	4.9	6.1	6.2	8.2	1.2	1.54	2.95	2.92
Zala	5.3	6.7	7.9	10.4	0.42	0.73	0.93	1.01
Zagyva	12.9	13.6	15.6	14.6	0.80	0.90	2.24	2.67
Danube								
Entrance	6.2	8.2	9.3	9.7	0.57	0.61	0.58	0.47
Exit	6.9	8.3	8.8	10.1	0.36	0.46	0.42	0.43
Tisza								
Entrance	2.5	3.6	5.0	4.8	0.10	0.16	0.09	0.09
Exit	5.7	7.8	12.3	12.0	0.11	0.22	0.29	0.11

Source: Hock, 1990.

Data from the entrance and exit stations of the Danube show no clear trends. However, a progressive deterioration can be seen along the Tisza for all water-quality constituents (*Table 10.2*).

Accidental water-pollution events affected surface water. In 1987, the number of such events was 262 (of which 214 were of Hungarian origin), and has increased by 3.2% per year in the period from 1978 to 1987. Of these events, 45% had to do with oil or oil products (Hock and Somlyódy, 1990).

10.1.4 Quality of bank-filtered water resources

The routine groundwater-monitoring network includes about 500 stations, but additional information is available from about 10,000 wells. In this chapter we are primarily concerned with bank-filtered resources, which play a significant role in the drinking-water supply.

About 85% of the water supply for Budapest comes from bank-filtered water resources along the Danube. The wastewaters from Budapest (only 21% of which is treated biologically) have an unfavorable impact on these resources. In the northern, upstream part of the river (on the Isle of Szentendre) the percentage of wells having objectionable water quality at all times is 9%, whereas this percentage increases to 46% in downstream, southern wells. This problem extends to pollution of the background (off-river) zone; for example, on the Isle of Csepel the groundwater has high concentrations of nitrate, organic carbon, iron, and manganese. The nitrate pollution levels are especially dangerous, exceeding 40 grams per cubic meter (the value specified in the Hungarian drinking-water standard as "tolerable") in more than half of the island. The nitrate concentration exceeds 200 grams per cubic meter in more than 5% of the island's area.

Due to increased loads of organic matter on the bottom sediment of the Ráckeve arm of the Danube (*Figure 10.1*), near anaerobic conditions are developing in some of the wells. This can result in an increase of iron, manganese, and ammonia concentrations in the well waters. The removal of these substances requires advanced (and expensive) water treatment. Although water extracted from the bank wells in the northern, upstream part of this water base can be delivered to the consumers practically without treatment (although its quality is deteriorating), water from wells of the southern, downstream water base (100,000 cubic meters per day) already requires the application of ozone treatment. This situation will be aggravated because Budapest will continue to dump its untreated wastes into the Danube, and there will be an increase in the drinking water extracted from the southern water base.

Some groundwaters with natural protection have a stable quality. In comparison, karstic and other groundwater resources, having no protection against pollution from the surface, exhibit deteriorating water-quality trends. An especially serious problem is nitrate pollution (for which the "utility gap" and agricultural non-point-source pollution can be blamed), which has required an emergency "plastic bag" water supply for about 700 settlements with 300,000 inhabitants.

Problems related to dissolved solids content, methane, iron, and arsenic concentrations in the groundwater occur of varying severity in different regions of the country. Bacterial contamination of traditional dug wells is also a problem. Faulty construction and illegal disposal of solid and liquid wastes have resulted in groundwater-pollution problems and accidental pollution events that were recently revealed to the public. Unfortunately, the occurrence, or rather awareness, of such events can be expected to increase.

10.2 Special Water-Quality Problems

10.2.1 Management of Lake Balaton eutrophication

Lake Balaton is one of the largest shallow lakes in the world and also the most important recreational area in Hungary (*Figure 10.1*), as well as an outstanding national asset. The water-quality situation of the lake has been well documented in the literature (Somlyódy and van Straten, 1986).

The artificial eutrophication of Lake Balaton was due to the increase in the tourist-related pollution, intensification of agricultural production in the watershed, and the much faster development of public-water supply than that of the sewage network and wastewater treatment. These factors contributed to an order of magnitude increase in nutrient loads to the lake from 1960 to 1980.

The first symptoms of eutrophication in the lake were recognized in the mid-1940s. Nevertheless, policymakers in Hungary did not become concerned until two major fish kills and unfavorable changes in phytoplankton structure occurred in the early 1980s. A dramatic sign of the change in phytoplankton was the mass invasion of a filamentous blue-green species, *Anabaenopsis raciborskii*, in the summer of 1982.

Many researchers from different disciplines devoted their attention to the problems of the lake after it was selected as a case study for the shallow lake eutrophication project (1978–1982) by IIASA. The objective of the first half of the cooperative study with several Hungarian institutions was to synthesize knowledge from different disciplines in the form of a decision model. The second stage was more policy oriented. By early 1982 details of a management strategy were available, which included an estimate of the spatial configuration and costs of control measures as well as an estimate of the water-quality improvement expected from these measures. Control variables in the decision model represented "protective" actions such as upgrading biological sewage treatment, the introduction of phosphorus precipitation treatment, or the construction of reservoirs for collecting nutrients of agricultural non-point-source origin. Obvious conflicts and trade-offs among agricultural production, tourism, and environmental protection were not taken into account.

The Council of Ministers in Hungary launched a policy-making program in early 1982 which included representatives of three counties and three water districts in the Balaton region and seven ministerial agencies, in addition to members of expert committees formed by the Hungarian Academy of Sciences.

About half a year was spent on negotiations between the various parties. Some of the agencies formed their official point of view in advance and expected experts belonging to their institutes to support this opinion. The Ministry of Agriculture launched a monitoring program and "justified" that the contribution of non-point-sources to the total nutrient load of the lake was negligible (for example, sampling during rainfall events was avoided). One lobby argued that the quality of water was actually improving. Another opposed any conclusions coming from modeling exercises. A third lobby doubted that phosphorus removal would have any positive impact. Government officials insisted that analysts must deal not with economics and cost-effectiveness, but with ecology and water quality. In spite of these difficulties the result was unique for Hungary. In early 1983 the government adopted short- and long-term objectives for the period from 1983 to 2010 for various basins of the lake (in terms of phosphorus loads and chlorophyll-a concentrations), as well as plans for measuring, budgeting, and monitoring (Láng, 1986).

Most of the control measures prescribed by the end of 1987 for the first stage of the estimation plan have been realized. Upgrading phosphorus precipitation and improved disinfection were introduced at 10 sewage-treatment plants; the regional sewage-treatment system was considerably expanded; and the first segment (about 20 square kilometers of surface area) of the Kis-Balaton reservoir, at the mouth of the Zala River (*Figure 10.1*) draining half of the lake's watershed, has been established. Two items of the original plan were not realized: phosphorus removal at the treatment plant of the largest city of the region, Zalaegerszeg, started operating only in 1990 (because of technical difficulties and institutional reasons) and the construction of the second segment of Kis-Balaton (*Figure 10.1*) has been postponed indefinitely due to budget problems.

As a result of the control measures taken, the total amount of phosphorus entering the lake has been halved and deterioration of water quality has been stopped. However, no improvement has yet been observed; in the most eutrophic western region of the lake, peak chlorophyll-a concentrations close to 150 milligrams per cubic meter can still be observed in late summer. There are two explanations for this: the amount of phosphorus produced "internally" by the lake through leaching processes in its sediments is as large as the amount dumped into the lake by "external" pollution sources in the 1980s; also the nitrogen-fixing blue-green algae produce nitrogen for phytoplankton growth. In other words, it seems like nutrients originating from either the air or the soil currently control water quality in the lake.

The next step for realizing the original plan is to evaluate the effectiveness of measures taken in the first stage and to plan the actions of the second stage. Unfortunately, the restoration program has not continued because of the economic recession, the attention given to other environmental problems, and political changes.

10.2.2 The Gabčikovo-Nagymaros Barrage System

The Hungarian and Czech-Slovak governments have been planning to build a complex hydropower scheme for the Danube upstream of

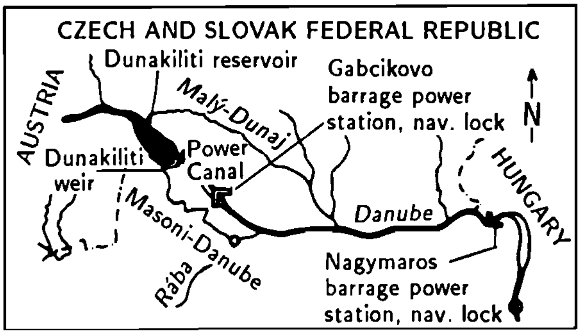

Figure 10.4. General layout of the Gabčikovo-Nagymaros Barrage System.

Budapest since the early 1950s. After long negotiations, the two parties agreed on a plan for the complex in 1973. The intergovernmental contract for construction was signed in 1977. According to the concept, two low-head hydropower plants were to be built (*Figure 10.4*). The upper part was to include a reservoir of about 200 million cubic meters (62 square kilometers) at Dunakiliti – a 25-kilometer canal that would divert the flow of the river to the turbines of the Gabčikovo power station (discharge capacity 5,200 cubic meters per second) and use of the old course of the Danube as a flood way. According to these plans a minimum of 50 cubic meters per second would be released to the old Danube (the annual average flow of the Danube at Bratislava is approximately 2,000 cubic meters per second) which was to be increased to about 200 cubic meters per second until the diversion canal reached the Danube. Side arms of the river were to contribute to this flow. The Gabčikovo power plant was to provide peak power with a capacity of 720 MW (water release would take place twice each day if the current flow was large enough).

The other component of the scheme at Nagymaros (*Figure 10.4*) was to have two functions in addition to the generation of 160 MW power: to provide a navigational waterway prescribed by the Danube Commission and to regulate the strong water-level fluctuations caused by peaking operation at the upstream power station.

Following is a brief chronology of events related to environmental issues of the Gabčikovo-Nagymaros scheme:

- 1976: The final report of a UNDP/WHO (1976) project dealing with water-quality management calls attention to possible negative impacts of the barrage system on the water quality of the Danube.
- 1976–1978: The Water Resources Research Center (VITUKI) and the Danube Research Station of the Hungarian Academy of Sciences recommend a comprehensive research program to study the impacts. There is no response from policymakers who do not share these concerns.
- 1978: Construction work begins.
- 1982–1984: The newly born Green movement in Hungary concentrates its efforts against the river dam project. The concern of Hungarian citizens, in general, grows. Their attention is centered on bank-filtered water resources, natural water treasures and ecosystems, deterioration of water quality, loss in genetic resources, and historic and aesthetic values. The government does not react.
- 1983: The construction on the Hungarian side is suspended because of environmental concern and lack of funds.
- 1985: An "environmental impact assessment" is performed by the planning office in charge of the design from the Hungarian side. Only the planned alternative is evaluated. Concerns about water quality remain unanswered in this report. A comprehensive cost-benefit analysis is also missing.
- 1986: Construction is accelerated after a contract is signed between Hungarian and Austrian companies on Nagymaros barrage (also credit is guaranteed by the Austrian government).
- 1988: The government informs the parliament about the situation regarding construction of the dam complex. In contrast to the original objective of maximizing energy production, the need for ecologically safe operation is emphasized for the first time. Investment cost is estimated to about Ft50 billion (approximately US$10 billion) which could be doubled due to additional costs of wastewater treatment and other measures to be taken to compensate likely adverse impacts of the dam complex. In spite of demonstrations against the barrage system the parliament approves the continuation of construction.
- 1989: After more than a hundred thousand signatures have been collected by protest movements against the dams, the parliament

reconsiders the issue. This leads to the cancellation of the Nagymaros river barrage under construction (together with the peak operation mode of the Gabčikovo power station as a consequence) and the suspension of the construction of the upstream barrage (95% of which is already completed).

- 1990: The new Hungarian government declares its intention not to put the Gabčikovo power station into operation. At the end of the year it decides to initiate negotiations with the government of the CSFR to modify the intergovernmental contract signed in 1977.
- 1991: Negotiations continue; although the government of the CSFR is willing to modify the original scheme, its objective is still to operate the upstream element of the system as soon as possible. In the meantime, Green movements in Slovakia are becoming increasingly active; frequent demonstrations take place at the construction site opposing the completion of the upper dam.

The failure to complete the Gabčikovo-Nagymaros System has resulted from overlooking several interrelated problems of water quality and quantity, the increasing environmental sensitivity of society, and a lack of proper policy-making procedure supported by comprehensive analyses.

Several quantity and quality problems remain. The quantity problems are related to the strongly reduced flow in the "old" river bed and to expected changes in the groundwater regime. The water-quality problems of the "old" Danube bed, having a flow of only 50 to 200 cubic meters per second, would likely be related to the sluggish water movement (mean flow of the Danube is about 2,000 cubic meters per second). A periodic flushing of the impoundment, at the expense of power production, could have partially resolved these problems. The expected changes in groundwater levels could have been compensated by a recharge system that transports water from the interception upstream drainage canals to the downstream canals and to the side arms of the Szigetköz, thus recharging the aquifers.

The expected water-quality problems would be mostly related to the trophic condition of the Danube. During the past three decades the nutrient loads in the Rajka section of the Danube have increased by 5 to 10 times due to upstream pollutant discharges. Nevertheless, the transparency of the river has improved due to the many upstream impoundments. These two factors resulted in a strong increase of algae. Today the chlorophyll-a concentration, a measure of algal biomass, is 50 milligrams per cubic meter on average (with upper extremes exceeding 100 milligrams per cubic meter) and increases downstream with distance. Due to the water storage contemplated for this project, the average flow velocity will decrease to one-fourth or one-fifth of its original value, increasing the theoretical residence time from 17 to 68 hours, as a function of the incoming flows. At the same time, the sedimentation rate of suspended matter will increase, thus increasing the transparency of the water. Temperature conditions will also be modified: warming up is expected, mainly in summertime. Taking into account the abundant nutrient supply conditions, all these factors will result in a doubling of the algal biomass at the end of the summer (as revealed by mass-balance calculations), and chlorophyll-a concentrations exceeding 200 to 300 milligrams per cubic meter might also occur in the flood plains of the reservoir (Somlyódy *et al.*, 1989).

Nevertheless, the lack of in situ experiments, especially in those parts of the reservoir that lie over current flood plains, increases the uncertainty of these predictions. These shallow water bodies will most likely be fully penetrated by light (except during storms), while their residence time will still be long. These factors might explain why the uncertainty analyses, based on a Monte Carlo simulation, predict extreme chlorophyll-a concentrations of 500 milligrams per cubic meter over the flood plains. The respective outflow concentrations would be 200 milligrams per cubic meter (Somlyódy *et al.*, 1989).

Increased algal biomass will result in increasing internal loads of organic matter. As contrasted to sewage-induced organic loads, this internal load will increase downstream with distance (in the growing season) due to growth rates that exceed mortality rates. This means that the quality of a relatively long downstream reach of the river will deteriorate due to the construction of the Nagymaros reservoir (Somlyódy *et al.*, 1989). As a result of these effects, the organic loads would increase in the growing period even if all sewage discharges of the drainage basin downstream of Rajka were biologically treated.

Increased algal biomass (the "secondary" pollution due to decaying algae) would certainly require a modification of current water-treatment technologies for the surface-water intake of Budapest. Increased organic loads will unfavorably affect the production processes of bank well-based drinking water. There will be a tendency for anaerobic conditions to occur in the sediments, thus increasing the chance that ammonia, manganese, and dissolved iron will occur in the water. The occurrence of these substances will require the modification of the water treatment given to Budapest's drinking-water sources.

The assessment of expected water-quality conditions is further complicated by the peaking-operation mode. There has been no assessment of ecological impacts in similar systems elsewhere. However, an analogy can be drawn with a river that has tidal fluctuations and is heavily loaded with sewage. Using this analogy, it was estimated that the dissolved oxygen level in the Mosoni branch of the Danube (*Figure 10.4*) would already be so much lowered by the peaking operation that biological treatment of sewage in Győr would be unconditionally required, as would a reduction of storm-water organic loadings (Somlyódy *et al.*, 1989).

The Gabčikovo-Nagymaros project was handled by previous governments as a political issue. The judgment of the new government is just the opposite to that of the earlier ones, but open questions and doubts related to the environment have not been analyzed scientifically just as in the past. The only acceptable professional way of treating the project would be to conduct an environmental impact assessment starting from the current situation, as recommended by a committee of the Hungarian Academy of Sciences in early 1990. However, there seems to be very little support for such systematic analysis. The issue is still too politically and emotionally confused; while canceling the project is the only acceptable political step, it does not reflect a good decision-making procedure.

Finally, it should be noted that the cancellation of the dam system leaves the problem of navigation over low flow conditions in certain river reaches: the opening of the Danube-Main-Rhine international waterway will likely worsen this situation.

10.3 Future Needs and Priorities for Environmental Protection

The following is a list (not necessarily in priority order) of the more important local and regional water-quality problems which should be solved:

- There is the overall problem of water supply, sewage, and sewage treatment. The well-defined needs of these items are not proportional to the budget available for the coming two decades. The inadequacy of sewage infrastructure leads to pollution, and hence a careful strategy is needed to deal with these problems comprehensively. This should include an upgrading of existing facilities (for example, chemically enhanced mechanical treatment) and the change of systems of water pricing and sewage fines.
- The poor quality of rivers with low dilution capacity and self-purification capability, which receive untreated or partially treated wastewater from the larger cities in Hungary, is another problem (*Figure 10.2*).
- More than 80% of the drinking-water supply of the country comes from groundwater resources. Actually the range of actions for protecting these resources is quite limited, and perhaps only the control of nitrate contamination from sewage and agricultural sources is feasible. Rehabilitation of karstic water resources requires time. A permanent risk to groundwater sources, however, will be caused by illegal waste-disposal sites; the control of these sites, especially from closed industrial and military plants, will be a major task of the future.
- For Lake Balaton, measures in the first phase of the remedial program have been taken. However, their effectiveness has not been evaluated; nor have the steps needed to meet the targets of the second stage been specified. It seems necessary to increase the amount of tertiary sewage treatment and to construct the downstream reservoir of the Kis-Balaton (*Figure 10.1*).

  In the meantime new problems have appeared (for example, a drinking-water shortage has occurred because of droughts). The reduced inflow at the northwestern region of the lake (*Figure 10.1*) is due to the abolishment of bauxite mining (extracted water was discharged to the lake). Bauxite mines were closed because of the dramatic reduction of the thermal water supply of Lake Héviz (close to Keszthely), one of the largest lakes fed by thermal springs in the world.

- The example of the Gabčikovo-Nagymaros Barrage System was discussed at length in Section 10.2. Negotiations between the two countries for finding a compromise solution would require the systematic analysis of various alternatives.

  There is an additional issue to be mentioned in relation to the Danube: the impact of Budapest on the river's quality as reflected by bacteria and of heavy metals present in bank-filtered water resources. The policy questions cover the decision to treat communal and industrial sewages, as well as protection of bank-filtered water resources, maintaining (improving) the recreational value of the Soroksár-Danube downstream of Budapest, improving the overall quality of the Danube, and the sequence of measures to be taken under given financial constraints. The answers require careful analyses: for example, it must be decided which actions should be taken to avoid a crisis in the coming decades.

  The water-quality problem of the Danube has a strong international dimension: without a basic change in the present inefficient cooperation the downstream riparian countries cannot successfully manage their water quality.

- Other important water-quality issues occur in the heavily industrialized regions such as Bakony, northeast of Lake Balaton, or the Sajó Valley in the northern Middle Mountains (*Figure 10.2*). About 10% of Hungary's total industrial production originates from the Sajó Valley including iron and steel production, metallurgical works, cement and concrete panel production, and glass making. A significant petrochemical complex is also found in the region, together with several cities (including Miskolc, the second largest city in Hungary). As a consequence of inadequate wastewater treatment together with upstream pollution (of communal and industrial origin) coming from the CSFR, the Sajó River has perhaps the poorest quality (class III) in Hungary (characterized by high concentrations of COD, NH_4^+, NO_3^-, PO_4^{3-}, heavy metals, oil, and lignite compounds). The Sajó River subsequently contaminates the Tisza River and the Kisköre reservoir. If we also consider water availability and distribution problems, the management of these industrial areas is a complex, regional problem.

10.4 Institutions and Legislation

Hungary, like all the other Central and East European countries, is currently undergoing a difficult transition period. There is a unique opportunity to change environmental policies and practices according to current needs and not necessarily by copying industrialized countries. However, there is a danger: if environmental policies are not properly reshaped now, several decades could be lost.

The situation is difficult because the shift toward a market economy is obviously associated with a strong decentralization of the earlier political system, unclear property relations, significant privatization, the rapid growth of small enterprises (focusing primarily on economic growth and not on possible adverse impacts on the environment), and the transfer of Western technologies (which are unfortunately often outdated, and contribute to the pollution problem). There is an opportunity to link the reshaping of the economy with the regulation of environment; indeed this is the only way to prevent pollution and to achieve long-term cost-effective solutions at the national level. At the same time, however, the economies of Central and East European countries are in such bad shape that governments might be forced to consider only the short run and to continue environmental management as an external factor. The other real danger is that the decentralization of control to local authorities and governments will take place before objectives and priorities can be defined for environmental protection.

The situation is particularly confusing in Hungary because environmental protection and water management were separated in 1990 (after being joined for the first time in 1988). The underlying cause was the issue of the Gabčikovo-Nagymaros Barrage System (often called a national tragedy), which is an example of a water project with likely adverse impacts on the environment. It also is a product of an institutional hierarchy, which operated without any controls from outside. Consequently, the decision of the new government to separate water management and environmental protection was a step which satisfied both society and all political parties. However, from the point of view of professional water and environmental management, the decision was arguable (although experiences from other countries show that many different systems can operate smoothly). It is likely that the decision to separate water and environment management cannot be easily realized. Indeed, there is an unclear connection between water-quality management (belonging to the Ministry of Environment and Regional Development) and water management (under the Ministry of Public Transportation, Telecommunication, and Water Management), as well as between the environmental and water-district authorities and local governments (counties, towns, and so on).

Another urgent task in the Central and East European countries is to work out proper countrywide monitoring and water-quality classification systems and standards, as well as the structure of fees and fines (as an element of a broader incentive system). With regard to the monitoring system in Hungary, it is considered one of the best organized systems in Europe (in terms of the number of components and spatial distribution of sampling stations). However, monitoring should be conducted for hydrobiology and ecotoxicology indicators. Also, the accuracy of estimating pollutant loads should be increased. The monitoring system should be modified in these ways even if the number of overall sampling sites must be reduced. The classification of water quality should definitely be modified as it now leads to more optimistic conclusions than justified on the state of the water environment (Somlyódy *et al.*, 1990).

In Hungary, an effluent standard system is operating with provisions to define standards for receiving waters in special cases. Total fines in the mid-1980s were approximately Ft300 million annually (approximately US$6 million) and were not proportional to the damages caused (the average fine was very low, Ft1 to Ft3 million) and, therefore, did not encourage development of sewage treatment. For details of environmental legislation in Hungary, see Kilényi (1990).

Clearly, the system of standards, fees, fines, and water pricing has to be changed. Major features of such a system should include the following:

- Standards should gradually approach the norms of the European Community (an immediate adjustment would be unrealistic).

- The elaboration of geographically varying standards is recommended for the countries which reflect environmental priorities and economic constraints, even if refined regulatory activity is necessitated.
- Receiving water standards should be used for water-quality management in cases where the impact of pollutant loads can be reliably evaluated.
- Fees and fines should be significantly raised (say, by an order of magnitude) to provide reasonable incentives to diminish pollutant discharges according to specific objectives. They should reflect the nature and impact of the pollutant considered.

10.5 The Need for Training and Technology Transfer

Although skill and scientific knowledge is available in Central and Eastern Europe in many fields of environmental and water-quality management, these capabilities have not been utilized for solving practical problems. There is a gap in science between West and East, but the gap is much wider at the level of applications and solving real-life problems than at the theoretical level.

In Hungary, at least three universities offer training in environmental protection. However, the experience of Western universities collected over the past two to three decades has hardly been utilized. Education is too theoretically oriented, and practical feedback is missing. Environmental experts from Eastern Europe are too academic not only because of their lack of applied work, but also because they do not appreciate the need for integrating various disciplines in environmental studies.

If environmental legislation and institutional changes are accomplished promptly, it is believed that professionals, institutes, university departments, and consulting companies will soon be available and they will quickly help in solving water-pollution problems. This development will automatically stimulate technology transfer from industrialized countries and improve training in the environmental sciences. Environmental education should be modernized systematically. It is important to train skilled environmental engineers with good foundations in computer sciences and modeling techniques, chemistry, and biology, in addition to traditional engineering. The role of environmental economics is particularly important: practically no such training exists in Central and East European countries.

Carefully organized technology transfer is necessary for training future environmental administrators, officers, technicians, and decision makers of district authorities and local governments to handle the reformed environmental protection system. The courses should cover experiences of industrialized countries with emphasis on the special needs of Central and Eastern Europe: this is not an easy task, particularly considering the limited knowledge of West European languages in the region.

10.6 Final Points

On the basis of information in this chapter, we can draw several policy-oriented conclusions:

- The downstream character of Hungary calls for cooperation in water management with neighboring countries.
- Pollution problems are less serious in Hungary than in other Central and East European countries.
- Environmental problems are scattered throughout the country following the spatial distribution of urban and industrial centers.
- No especially dramatic problem exists; therefore priorities cannot be easily pointed out.
- Investment requirements are still enormous: the development of sewage systems and wastewater treatment would necessitate at least US$5 billion.

In summary a well-tailored, countrywide water-pollution-control strategy is needed which defines short- and long-term objectives and priorities. Under existing economic constraints, the preparation of such a program is extremely difficult to realize.

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Chapter 11

Air-Pollution Problems and Priorities in Hungary

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After World War II, Stalinist-style economic policies led to extensive industrialization in Hungary. At the same time, collectivization of farming led to a movement of people away from the land and into the cities. The energy source used to fuel these new industrial settlements was mainly low-quality brown coal which resulted in severe air-quality problems. For example, by the 1950s SO_2 emissions in Hungary were around 2,300 kilotons per year, and soot and ash covered crowded industrial areas.

After several smog episodes caused near darkness during daylight hours in the center of Budapest, the city council began to take air-pollution abatement measures. Coal heating was phased out of inner city districts, and about 300 industrial plants were obliged either to install pollution-control equipment or to remove the sources of pollution from the capital.

The Air Pollution Act of January 1973 listed three categories of protected areas. It also introduced emission standards and imposed fines for violations of these standards. The pollution-control program, initiated and funded by limited subsidies, was only able to solve part of the urgent environmental problems that arose under the centrally planned economy.

Changes in the energy structure since the 1960s have had an important effect on the present air-pollution situation. These changes included the growing use of oil and natural gas based on imports and increased exploitation of domestic resources; import of electricity through the integrated system of the Council of Mutual Economic Assistance (CMEA); completion of a nuclear power station in 1987; and energy conservation. These measures, plus a decline in industrial output, resulted in the improvement of some aspects of air quality in several settlements. One clear sign of improvement was that national SO_2 emissions decreased by 50% during the last 30 years. Emission of particulate matter also decreased significantly, in part owing to implementation of controls.

Unfortunately, rapidly growing road traffic offset the pollution control accomplished elsewhere during the last decades. In earlier Stalinist times owning a car was a special privilege; today, however, the number of car owners in Hungary has already dramatically increased. Cars are a major source of air pollution because the average age of vehicles on the roads is higher than in the West. In addition, more than 90% of the vehicles produced are inefficient models, requiring high maintenance. One-third of the motor vehicles in the region are powered by East German two-stroke engines. These vehicles are responsible for 40% of the national air-pollution emissions; in some urban areas vehicle exhaust is the main cause of quality deterioration.

11.1 Ambient Air Quality

The Regional Air Quality Monitoring Network, operated by the Public Health and Epidemiological Stations have provided data on SO_2, NO_x, soot, and particulate matter since 1974. Automatic samplers are in operation at some 400 stations in 106 settlements, with a telemetric system serving the capital.

Air-quality standards for Hungary are given in *Table 11.1*. Air quality is less than satisfactory in more than 11% of the country containing 44.3% of the population. These areas are situated mainly along the western to northeastern axis of the country (*Figures 11.1* to *11.3*). Health

Table 11.1. Ambient air-quality standards.

	Concentration ($mg\ m^{-3}$)		
	Specially protected areas	Protected areas I	Protected areas II
SO_2			
Annual average	0.03	0.07	0.15
24-hour average	0.10	0.15	0.50
30-minute average	0.15	0.50	1.00
NO_x			
Annual average	0.030	0.070	0.12
24-hour average	0.070	0.085	0.15
30-minute average	0.085	0.100	0.20
CO			
Annual average	1.0	2.0	5.0
24-hour average	2.0	5.0	10.0
30-minute average	5.0	10.0	20.0
Suspended particulates			
Annual average	0.03	0.05	0.10
24-hour average	0.06	0.10	0.20
30-minute average	0.10	0.20	0.30
Lead			
24-hour average	0.0003	0.0003	0.001
30-minute average	0.0003	0.0003	0.002
Ozone			
24-hour average	0.10	0.10	0.10
30-minute average	0.20	0.20	0.20

injuries attributable to air pollution are estimated to cost more than Ft4 billion each year. According to the findings of a Hungarian study, asthma and bronchial diseases steadily increased in children ages 7 to 17 between 1975 and 1984. In polluted towns and heavily polluted districts of Budapest, pathological alterations occur in children four times more frequently than the average. The occurrence of chronic adult bronchitis is three times the national average.

As noted earlier, annual average SO_2 levels declined during the last few decades. Data on sulfur dioxide emissions in the 1980s are given in *Table 11.2*. NO_x levels are fluctuating (*Table 11.3*), but other components of road traffic (carbon monoxide and volatile organic carbon,

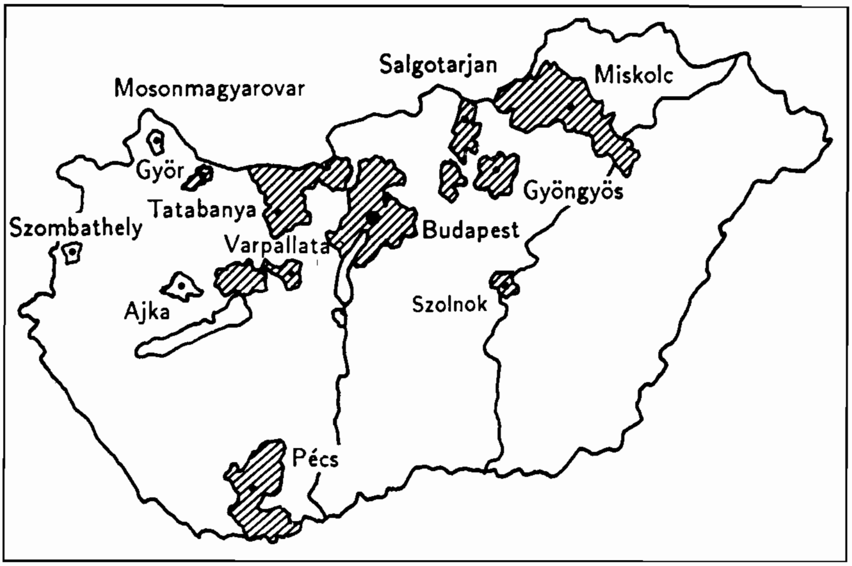

Figure 11.1. Areas heavily polluted by sulfur dioxide.

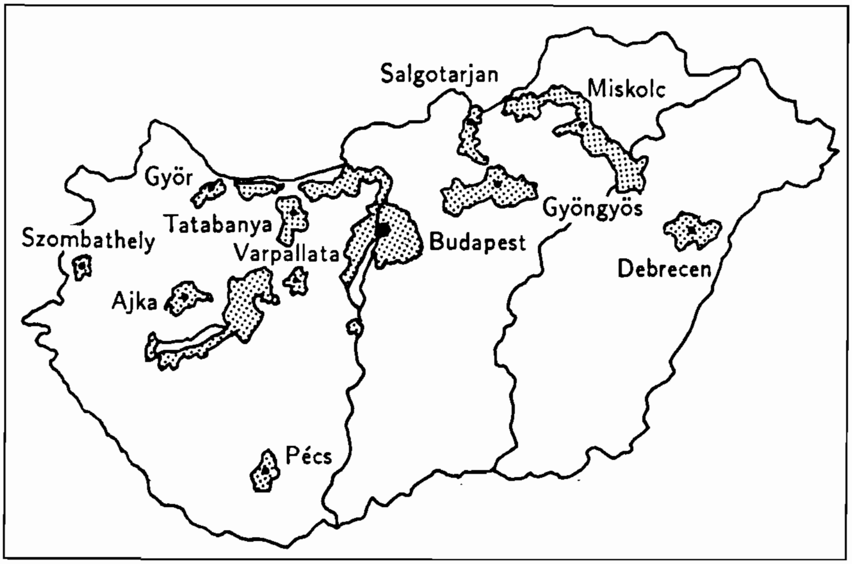

Figure 11.2. Areas heavily polluted by nitrogen dioxide.

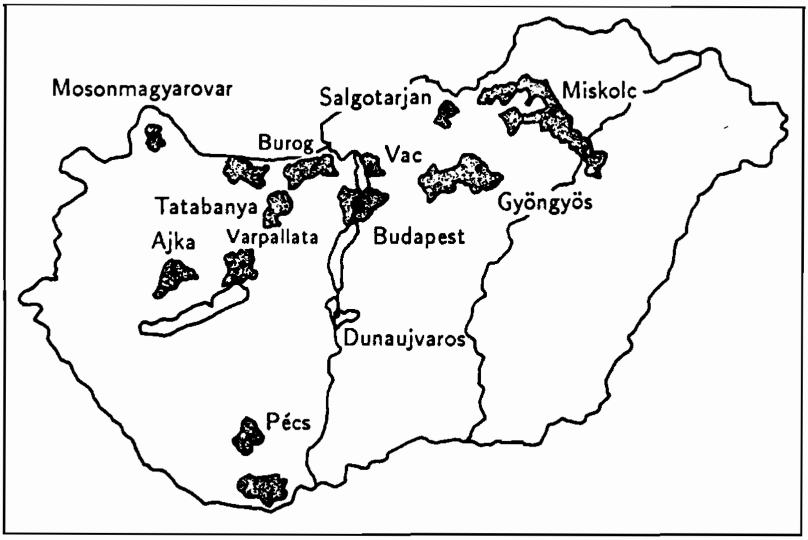

Figure 11.3. Areas heavily loaded by particulate matter deposition.

Table 11.2. Sulfur oxide emissions, in kilotons per year.

	1980	1985	1986	1987	1988	1989
Power plants and district heating	344	263	273	275	238	225
Industry	216	244	240	203	199	158
Domestic	146	152	137	130	135	125
Mobile sources	24	10	9	9	9	8
Others	41	33	26	29	28	26
Total	771	702	685	646	609	542

VOC) are increasing in urban air (*Table 11.4*). Despite the 30% decrease (from 0.6 to 0.4 grams per liter) of lead content in gasoline in 1985, lead concentrations along main roads still sometimes exceed health limits by several orders of magnitude. Dust deposition is very heavy at some industrial settlements. In addition, alkaline rains with pH up to 8.5 often occur, originating from wind-borne soil particles.

Table 11.3. Nitrogen oxides emissions, in kilotons per year.

	1980	1985	1986	1987	1988	1989
Power plants and district heating	73	65	66	63	55	53
Industry	53	48	53	58	48	45
Domestic	18	22	20	21	21	20
Mobile sources	111	110	115	119	120	116
Others	18	17	14	15	15	15
Total	273	262	268	276	259	249

Table 11.4. Emissions from the transport sector in 1987, in kilotons per year.

Substances	Emission
Sulfur dioxide	21.0
Nitrogen oxides	110.0
Particulates	28.0
Carbon monoxide	497.0
Soot	4.6
Hydrocarbons	76.0
Lead	0.5

11.2 Trends of Sectoral Emissions

Sectoral variations of SO_2 and NO_x emissions are shown in *Tables 11.2* and *11.3*; emissions from the transport sector are shown in *Table 11.4*. Electric-power generation and district heating are still the greatest emitters of SO_2, although nearly 60% of Hungary's electricity is supplied by sources that produce no emissions within the country. Of the electricity used in Hungary, 28% comes from nuclear power stations, 28% is imported, and a small percentage comes from hydropower. The 800 MW Gagarin Lignite Power Plant alone emits more than 10% of the national total. With few exceptions, all utilities are equipped with electric precipitators. The World Bank is now financing the reconstruction of four coal-fired plants, increasing efficiency in the process by 10% to 15%.

The result of energy savings and an economic recession can be seen in the decreasing emissions trend of the last years in the industry sector. However, emissions from some industries are still significant. For example, particulate matter from cement factories and steel-manufacturing works, NO_x from three fertilizer plants, fluoride from aluminum smelters, and VOCs and metals from the oil, ceramic, and other industries are still very substantial.

Domestic sector data show fluctuating SO_2 and NO_x resulting from the partial conversion in 1985 from oil to coal or gas. At the same time the sulfur content of light heating oil and diesel oil was decreased by 50%, decreasing SO_2 emissions from mobile sources.

Hungary imports rather than produces chlorofluorocarbons (CFCs). Consumption in 1986 was about 6,000 tons (0.6 kilograms per capita). This usage has been moderately decreasing during the last years.

11.3 Priorities in Controlling Air Pollution

Despite efforts so far, ambient air quality is unsatisfactory in a significant part of the country. The most important tasks to further reduce air pollution are as follows:

- Implementation of a 30% reduction in SO_2 emissions is required by the Geneva Convention to reduce transboundary air pollution. To meet this target, the population should be supplied with fuels of low sulfur and ash content where district heating or natural gas are not available. Modifications of the energy system can improve urban air quality, especially levels of particulate matter and sulfur dioxide. Upgrading of coal should be enforced and the desulfurization of heating oils continued. Low-sulfur briquettes and fuel cakes from agricultural and forestry wastes should be produced, and more efficient heating equipment should be available.

  The highest priorities for SO_2 control for utilities and industries are combustion modification, that is, speeding up conversion to fluidized bed combustion. Results from pilot plants using these modifications are promising. Although several studies were completed, the introduction of flue gas desulfurization units seems to be unaffordable given the present economic situation of the country.

  Most of the dust filters have been operating for over 10 years. Despite regular maintenance their efficiency fails to meet present requirements, much less future standards. Their replacement in the next 5 to 10 years is unavoidable. This work is already under way in a few power plants within the framework of a utility reconstruction program financed by the World Bank.

With regard to long-term energy planning, the promotion of energy efficiency must be considered in addition to increasing generation capacities. The main task in the near future will be to develop an energy strategy that not only meets the national needs, but also takes into account regional and global requirements.

- It is imperative to reduce VOCs (pharmaceutical, paint, petrochemical, and machine industries), odors (leather industry, sewage treatment, and animal breeding), and inorganic materials and toxic metals (aluminum smelters and fertilizer and pesticide production).
- Mobile sources play an increasing role in the continuing deterioration of urban air quality. Although the number of such vehicles per capita is about half that of the industrialized countries, high fuel consumption and poor maintenance result in high emissions, especially of CO, VOCs, and NO_x. Recently, the government began to review possibilities of speeding up measures of mobile source emission control by the following means:
  - Introducing recent EC emission standards for new cars.
  - Installing catalytic converters or other emission-control equipment on existing vehicles.
  - Creating economic incentives for importing cars with catalytic converters.
  - Introducing an annual environmental checkup.
  - Developing methods for reducing urban traffic.
  - Decreasing the lead content of petrols and sulfur content of fuel oils and increasing the availability of lead-free petrol.
- As a party to the Montreal Protocol, efforts are being made to phase out CFCs and halons. Although industrial users have indicated their willingness to switch to CFC alternatives, these alternatives have yet to be provided.

In addition to these measures, an air-quality monitoring system is also necessary. Despite all efforts, progress is very moderate because of lack of capital. The new government is still unable to overcome the chronic economic problems it inherited. Introduction of a new economic regulation system stimulating environmental protection is required because the previous one seemed to be counterproductive.

Chapter 12

Problems of Municipal Sewage Treatment in Protecting the Water Resources of Poland

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Poland has a population of 38 million according to data from 1989; 61% lives in urban areas and about 39% lives in rural areas. The surface area is 312,683 square kilometers. The density of population is rising, and had reached an average of 122 people per square kilometers in 1989. Average annual rainfall is 617.6 millimeters. Water resources in Poland, expressed as the annual volume of river water flow into the sea, are equal to about 68.6 cubic kilometers per year on average and 30 cubic kilometers per year in dry years. This results in 1,542 cubic meters of water per person in normal years and 789 cubic meters per person during dry years. (Droughts occur in Poland roughly every four years, often occurring in two consecutive years.) These indices of water resources place Poland far behind many European countries. They also justify the description of Poland as a country poor in water.

12.1 Sewage Treatment in Poland

Overall consumption of water in Poland for various purposes was about 15.1 cubic kilometers per year in 1989. Of that amount, 20.3% was for domestic use, 68.6% was used by industry, and 11.1% was used by agriculture. Of the overall demand, 84.0% was met by surface-water resources and 13.9% by underground resources. These data show that during dry years surface-water uptake reaches about 42% by volume of annual resources. The difficulty in meeting demand is clear when the regional and temporal variability of river-water flow is taken into consideration.

Exploitation of water resources is made even more difficult because of sewage pollution. According to data from 1989, about 12.3 cubic kilometers of sewage was drained off annually in Poland, of which 7.9 cubic kilometers was so-called clean sewage (mainly water used in cooling systems). The remaining 4.4 cubic kilometers of sewage needed treatment. Thus, during dry years (which are the most appropriate years for assessing the situation), the ratio of annual flow in rivers to the amount of sewage that needs treatment is 6.8:1. The conclusion to be drawn from this ratio is that there is very little opportunity to dilute the sewage with river waters. Especially so as Poland's heavy industries are located in the upper courses of rivers where water flows are low.

It is clear that in such situations highly effective sewage treatment is needed. Unfortunately, of the 4.4 cubic kilometers of sewage that needs treatment, only 25% is treated both mechanically and biologically, 41% is partially (i.e., inadequately) treated, and 34% of the sewage is drained off into surface waters without any treatment. Of 825 Polish towns, only 459 were equipped with sewage-treatment plants (this number includes 292 towns with mechanical-biological plants); 366 towns had no treatment plants in 1988.

The consequence of this inadequate sewage treatment is the very bad condition of surface waters. There are three categories of water purity in Poland: category I includes water intended for drinking-water supplies and for industrial plants requiring equivalent water purity; category II includes water resources intended for livestock, public baths, and recreation; and category III includes water suitable for industrial uses only (except for those requiring drinking-water purity). Water purity in rivers examined in Poland according to estimates made from 1984 to 1988 is as follows:

- Conditions of category I were fulfilled in only 4.8% of the overall length of the rivers, as opposed to the 53% which should have been in this category.
- Conditions of category II were met in 30.3% of the overall length of the rivers, against a desirable target of 40%.
- Conditions of category III were fulfilled in 27.8% of the overall length of the rivers; the length of such rivers should have been equal to 7% of the overall length.
- Pollution worse than permissible for category III – that is, the category with the lowest standards – occurred in 37.1% of the overall length of the rivers.

This assessment of river pollution was determined using physicochemical parameters. When biological parameters are used, the results are even worse: only 0.1% of the overall length of the rivers examined fulfilled the conditions of category I, and as much as 75.8% of the length of the rivers did not meet the standards of category III.

The largest Polish river (the Vistula, which is the major source of water for many towns and industries) does not reach category I purity anywhere along its length, and 57.5% of it is so badly polluted that water quality is below category III.

12.2 Effects of Water Pollution in Poland

Obviously the pollution of the rivers affects the amount of pollutants drained off the territory of Poland into the Baltic Sea. This is illustrated by data collected by the Institute for Meteorology and Water Management in 1988 and presented in *Table 12.1*. The percentage of these loads from point and area sources is presented in *Table 12.2*.

Pollutants discharged from the territory of Poland into the Baltic Sea add significantly to the total mass of pollutants discharged into it by

Table 12.1. Pollutants loads discharged by rivers into the Baltic Sea from Poland, estimate for 1988, in tons per year.

Pollutant	Vistula	Odra	Other	Total
BOD-5	164,477	86,167.0	22,174.0	272,818
COD	1,004,357	663,915.0	187,775.0	1,856,047
Nitrogen	129,337	94,335.0	22,664.0	246,356
Phosphorus	6,929	8,383.0	1,709.0	17,021
Zinc	2,928	1,861.0	283.0	5,072
Copper	233	187.0	42.0	462
Lead	186	178.0	42.0	406
Mercury	39	37.2	6.8	83
Cadmium	13	20.2	2.8	36

Source: Institute for Meteorology and Water Management, 1988.

Table 12.2. Percentage of pollutant loads of Vistula and Odra rivers as they drain into the Baltic Sea from point sources and area sources, 1988.

Pollutant	Point sources	Area sources
Vistula		
BOD-5	32.4	67.6
COD	53.3	46.7
Nitrogen	32.8	67.2
Phosphorus	55.5	44.5
Odra		
BOD-5	43.7	56.3
COD	48.2	51.8
Nitrogen	34.3	65.7
Phosphorus	66.6	33.4

Source: Institute for Meteorology and Water Management, 1988.

all Baltic countries (*Table 12.3*). The amount discharged depends not only on insufficient sewage treatment in Poland, but also on the area and population of the country. A comparison of unit loads calculated per capita or per square kilometers of cultivated land in the Baltic countries is shown in *Table 12.4*. Unit loads of pollutants discharged from Poland are often lower than unit loads from other countries. However, because of its size and population, even relatively small decreases in the value of the unit load of pollutants coming from Poland can considerably decrease the absolute amounts of pollutants flowing into the Baltic Sea.

Table 12.3. Pollutants loads discharged into the Baltic Sea by the Baltic countries, as a percentage of the total load.

Country	BOD-5	Nitrogen	Phosphorus
Denmark	9.5	10.6	20.0
Finland	15.0	10.7	9.3
Former East Germany[a]	0.8	0.6	0.8
Poland	21.5	35.7	37.9
Former West Germany	1.4	2.5	5.1
Sweden	21.6	19.9	14.5
Former USSR Republics	30.2	20.0	12.4

[a]Without pollutants drained off into the Odra River.

Source: Report o stanie zagrożenie i ochronie środowiska, 1990.

12.3 Investment in Sewage Treatment

The degree of pollution of Polish river waters, and its influence on the pollution of the Baltic Sea, constitutes a real threat to the health of Polish citizens. It is also a barrier to the economic and social growth of Poland. Investment is urgently needed to remedy this situation, with improvements to urban sewage treatment being especially important.

Several aspects of urban sewage treatment in Poland have specific links to the overall state of the Polish economy. These links are:

- The disastrous condition of the rivers and the enormous construction backlog of urban sewage-treatment plants require heavy investment to build many new urban treatment plants.
- Protection of the Baltic Sea requires a higher level of sewage treatment than that required for protecting river waters alone. Therefore, the design of new urban sewage-treatment plants should take into account the need to protect the Baltic Sea.

Building so many sewage-treatment plants would put an unusually heavy burden on the Polish economy. Other Baltic countries, such as those in Scandinavia, have not suffered such burdens on their economies because they gradually built conventional mechanical-biological plants and then slowly added advanced treatment as it became necessary. For them, capital expenditures were spread out over a relatively long period of time. Poland is under pressure to undertake immediate intensive construction. The economic aspects of this implementation are illustrated

Table 12.4. Pollutants loads drained off into the Baltic Sea by the Baltic countries, estimate for 1986–1988.

	Point source in grams per head per day			Area source in tons per year per km^2 of cultivated ground		
Country	BOD-5	Nitrogen	Phosphorus	BOD-5	Nitrogen	Phosphorus
Denmark	32.30	10.4	2.35	1.77	1.57	0.0910
Finland	38.20	15.4	0.98	2.80	0.67	0.0353
Former East Germany[a]	4.60	1.1	0.15	0.24	0.09	0.0046
Poland	6.78	5.6	0.70	1.56	1.46	0.0575
Former West Germany	12.50	9.7	1.36	2.70	1.75	0.2685
Sweden	30.50	8.5	0.79	3.16	2.42	0.0421
Former USSR Republics	13.80	2.8	0.19	1.60	0.50	0.1420

[a]Without pollutants drained off into the Odra River.

Source: Institute for Meteorology and Water Management, 1988.

in *Figure 12.1*. Under Poland's current economic condition, it is not possible to build all the urban treatment plants required with capability to remove phosphorus and nitrogen compounds, although that would be desirable to protect the waters of the Baltic Sea. Because of the limited amount of capital for sewage treatment, it is important to maximize the improvement of water quality for these limited investments. This is obviously connected with selecting and mastering appropriate technologies for the removal of phosphorus and nitrogen compounds. The decision should be made to concentrate either on the removal of phosphorus or on the removal of phosphorus in conjunction with nitrogen.

To minimize the cost and maximize the benefits of treatment plants it is important to select the right size and number of plants. It is partly a question of economies of scale, with unit capital expenditure decreasing with respect to increasing plant size, as illustrated in *Figure 12.2*. Economy of scale favors building one large common treatment plant for adjacent sedimentation units over several smaller local ones. However, this economy must be weighed against the increased costs of sewage transport. Therefore, plant size and the area it covers have to be optimized. Under the current economic conditions in Poland, another factor often tips the scales in favor of building several small plants instead of one large plant: the practical difficulty of making a large capital investment. Large constructions tend to be more complicated and take longer to build, freezing capital sometimes for many years. In addition to economic losses, the implementation of sewage treatment is delayed. Also, sewage-treatment plants that have been under construction for a dozen or so years sometimes require renovation even before they have been put into service, an obvious absurdity.

The size of the new sewage-treatment plant becomes a very important issue when it must service an area beyond the boundaries of a town. Unusual difficulties in transporting sewage to the central treatment plant may arise in such cases. Difficulties caused are either technical (such as building a sewage conveyance under existing streets with the risk of damaging other subterranean facilities) or economic (high cost of sewage conveyance). A good example of the latter difficulty is the situation in the part of Warsaw on the left bank of the Vistula River; in this case a decision has been made to build two separate sewage-treatment plants (one for the southern part of the town and one for the northern – at

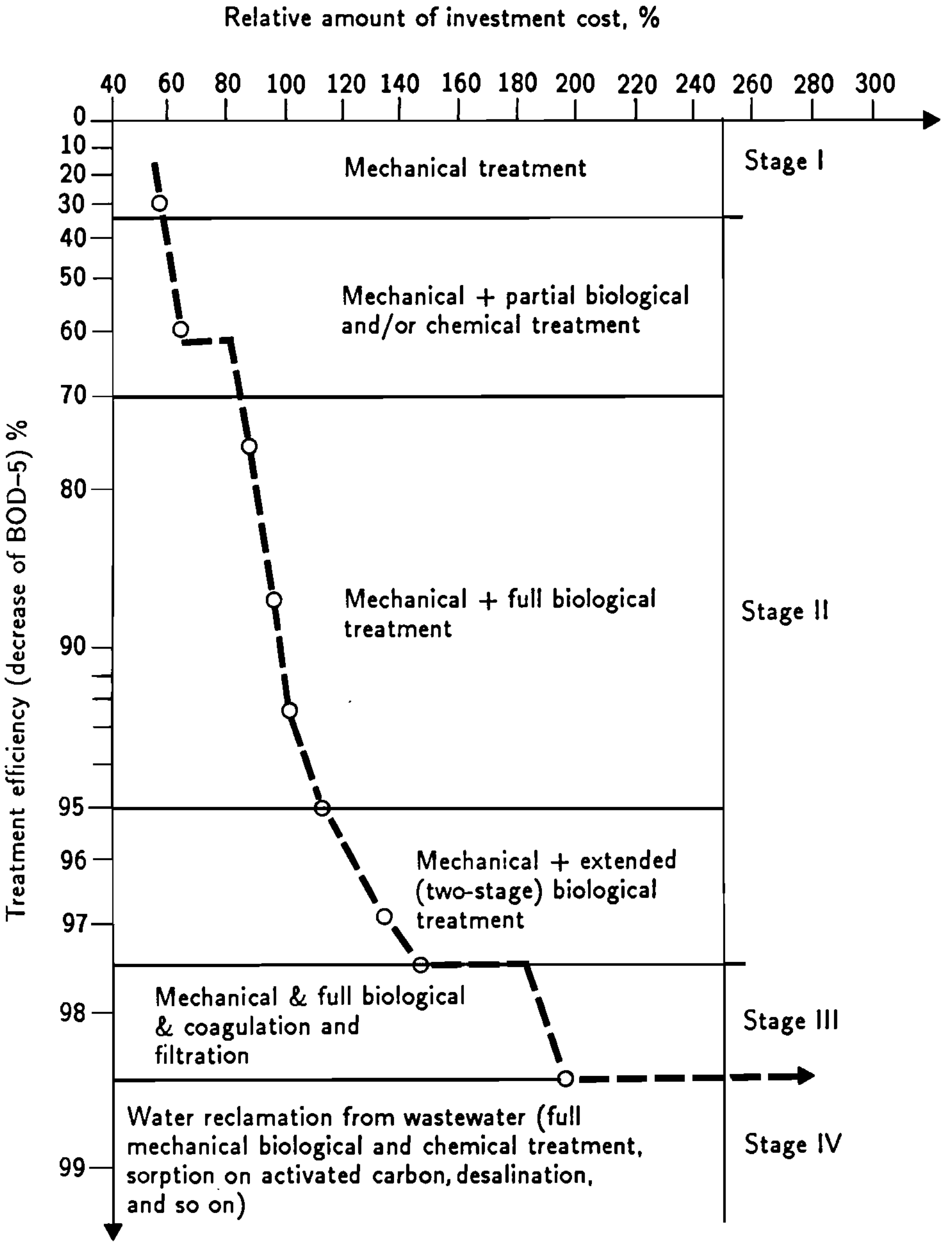

Figure 12.1. Dependence of investment cost of wastewater-treatment plants on tréatment efficiency.

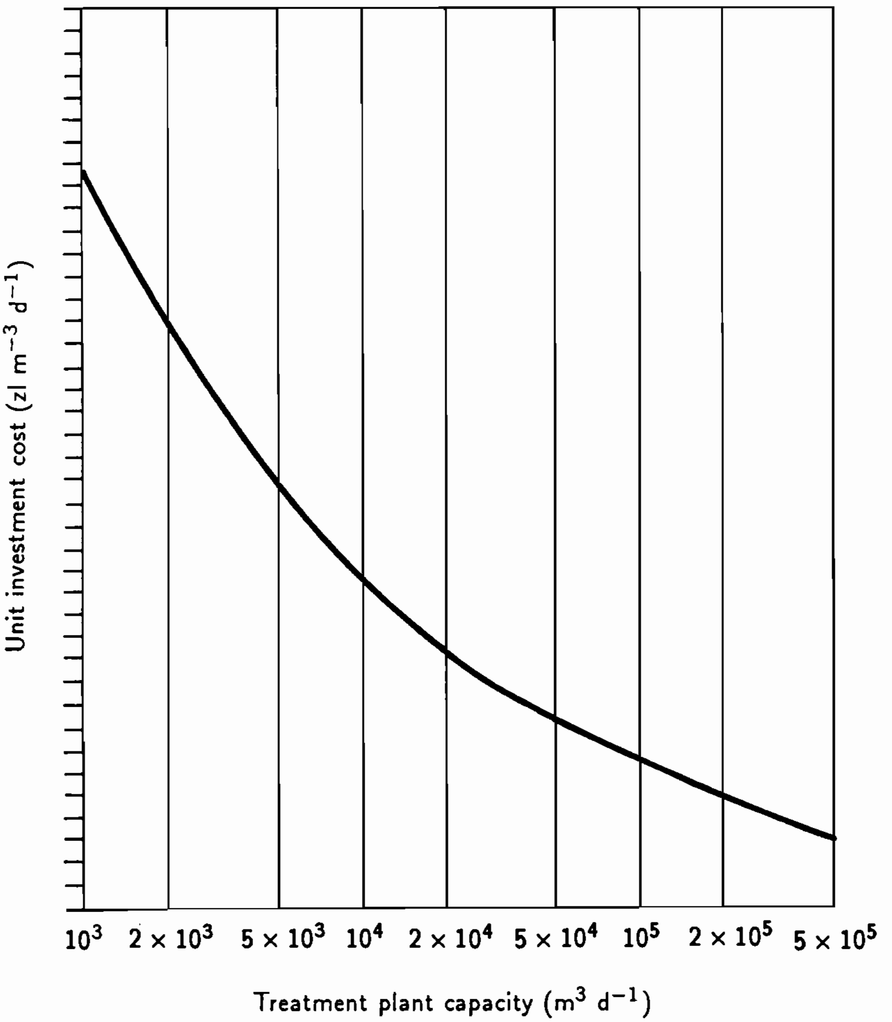

Figure 12.2. Dependence of unit investment cost of mechanical-biological wastewater-treatment plants on the capacity of the plants (treatment efficiency decrease of BOD-5 – 92%).

upper and lower reaches of the Vistula River, respectively) instead of a single sewage-treatment plant as previously planned, at the lower reach of the river (Błaszczyk *et al.*, 1988)

One of the most important factors to be considered during the design stage, especially when determining its location, is the management of bad odors. In practice, engineers in Poland use a positive approach by relying on the existence of a protective zone around sewage-treatment plants. The width of the zone varies from 200 to 1,000 meters according to the size of the plant. Setting up such zones causes many problems in selecting the location of the plant. Urban locations, for example, have to be assured of adequate protection of the surrounding area from harmful influence of the plant (Anon, 1987). An iterative approach to the problem is needed, relying on finding suitable technology and technical design solutions. Such solutions should eliminate odors (i.e., covering the active sedimentation chambers, sealing off sludge-processing units).

A special problem, which is immensely difficult to solve in Poland, is the processing and rendering harmless of the sewage sludge as well as its final removal from the plant and subsequent use. To solve this problem sludge-dewatering equipment is needed. Apart from that, it is necessary to find a way to use the sludge or to dispose of it. Although sludge has been used widely in agriculture, its use has now become unpopular among both farmers and the general public for hygienic reasons. The issue of sewage sludge is so far unsolved in Poland and in need of urgent attention.

Limited funds and very large needs for sewage treatment call for cost-effective solutions. The adoption of a suitable strategy of investment within the region or the river basin could bring substantial benefits. However, it requires a suitable method to assess the effectiveness of investments in water-resources protection. Various investigations have not come up with substantial results. High inflation and rapid price movement are additional factors making the analysis even more difficult. Under the current situation, therefore, it seems appropriate to replace the amount of capital expenditures by the cumulative amount of energy consumed. An estimate is also needed for the useful effect on a river basin of the planned sewage-treatment plants. Taking the above factors into account, the useful effect of the sewage-treatment plants can be determined by the equation

$$W = \sum_{i=1}^{n} L_i Q_i \left(\frac{S_{d_i}}{S_{k_i}} - \frac{S_{d_i}}{S_{p_i}} \right) , \qquad (12.1)$$

where W is the useful effect of the sewage-treatment plants in the given region; L_i is the length of part i of a river; Q_i is the total flow in part i of a river; S_{d_i} is the maximum permissible concentration of pollutants in part i of a river; S_{k_i} is the concentration of pollutants in part i of a river before construction of the sewage treatment plant; S_{p_i} is the concentration of pollutants in part i of a river after construction of the sewage-treatment plant; and n is the number of rivers considered in the region.

The useful effect of sewage-treatment plants computed in equation (12.1) would be the increase in water quality expected by situating the plant at a particular point along the river.

The ratio of energy consumed by treatment plants over the effectiveness factor W could be used as an index of the economic effectiveness of treatment plants:

$$E = \frac{P}{W} , \qquad (12.2)$$

where E is the index of economic effectiveness; P is the energy consumed by sewage-treatment plants in a given region; and W is the useful effect of the sewage-treatment plants in the region as determined by equation (12.1).

On the basis of such an index it is possible to analyze the effectiveness of investments in treatment plants that are constructed gradually. However, this approach requires a method to discount the value of energy consumed and of the useful effect.

12.4 Conclusions

Only a few problems concerned with the treatment of urban sewage in Poland have been described, with particular emphasis on the Polish economic situation. One important issue which has not been discussed is the importance of waste minimization to reduce the total amount of wastewater. Care should be taken to decrease the amount of the pollutants reaching wastewater.

Successful completion of the construction of the sewage-treatment plants in Poland obviously requires large funding to be accomplished. In addition, other actions are needed, such as:

- Developing expertise in building sewage-treatment plants and shortening construction time, currently reaching ridiculous lengths.
- Developing production capability for mechanical equipment, especially sewage aeration and sludge dewatering.
- Completion of repair works and updating existing plants to offset their depreciation.
- Using available methodology to optimize priorities for building sewage-treatment plants.
- Raising the status of employees of sewage-treatment plants by making their salaries commensurate with workloads, health risks, burdensome working conditions, and the required qualifications and level of responsibility.

These actions are straightforward, but they are also difficult to accomplish under current conditions in Poland. Let us hope that this situation will rapidly improve.

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Chapter 13

Air-Pollution Problems in Poland

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Information about the level of air pollution and its occurrence in different parts of Poland is of fundamental importance for proper economic and regional planning and for choosing the optimum strategy for protecting the atmosphere on the regional and national scale. Also this information makes it possible to estimate directly the threat to human health and to the natural environment.

Annual observations of changes in the concentration of air pollutants permit researchers to diagnose long-term trends and, subsequently, to assess the efficiency of steps taken in Poland, and in Europe in general, to protect the atmosphere. The basic way of obtaining this information is to implement a comprehensive air-pollution monitoring program. This program should include:

This chapter is based on information compiled at the Ministry of Environmental Protection, Natural Resources, and Forestry, and the Environmental Protection Institute, both in Warsaw, Poland.

- Emission measurements: measurements of the mass of dust and gas pollutants emitted into the air over a given time period (kilograms per hectare, tons per year).
- Ambient measurements: measurements of the concentration of dust and gases in the surface layer of the atmosphere, such as the layer inhabited by man (milligrams per square meters).
- Deposition measurements: measurements of the mass of a pollutant deposited annually in a given area (grams per square meter per year, tons per square meter per year).

This chapter describes the first attempt to comprehensively measure air pollution in Poland. The study uses data taken in 1987. Since there is neither a national system of recording these measurements nor instructions about the ways of analyzing and presenting them, this work may contain some inaccuracies or omissions.

13.1 Air-Pollutant Emissions

The largest anthropogenic sources of air-pollutant emissions in Poland are power stations (combined heat and power stations), industrial plants, motor vehicles, and dispersed emission sources in municipal, farming, and food-producing sectors. These sources, which rely on the burning of fossil fuels, emit large quantities of dust, sulfur dioxide (SO_2), nitric oxides (NO and NO_2), carbon monoxide (CO), and hydrocarbons (C_nH_m). In accordance with the Council of Ministers' regulation of September 1980, industries and power plants emitting more than 100 kilograms per hectare of SO_2 or dust should conduct manual measurements of this emission at least twice a year. Plants that emit over 1,200 kilograms of SO_2 per hour or 800 kilograms of dust per hour should use automatic analyzers to conduct constant measurements of these emissions. In addition, in accordance with the regulations of the Minister of Environmental Protection and Natural Resources of April 1987, all motor vehicles should undergo NO_x, CO, and C_nH_m emission controls during their regular checkups.

Regrettably, these regulations were not complied with in 1987 mainly because of the lack of automatic emission-control equipment in Poland. Manual measurements were also rarely taken because of the limited number of qualified personnel and insufficient equipment. The results of these measurements were often unreliable because different, nonstandardized measurement methods were used without the authorization of the environmental protection agency (*Table 13.1*). Moreover, no standardized records of the results were kept.

For these reasons, an estimate of the annual release of different pollutants cannot be based on the national monitoring data of either the voivodship (province) or the nation. It was necessary, therefore, to rely on material balance sheets and on emission factors characteristic of different technological processes. The Central Statistical Office (GUS) uses this method to obtain information about pollution. In 1987 this system was applied to 1,200 of the largest and most troublesome power stations and industrial plants. The GUS report did not take into account, however, tens of thousands of smaller plants, vehicles, and pollution sources in the municipal, farming, or food-processing sectors.

This chapter attempts to supplement the GUS data on the release of dust, SO_2, NO_x, and CO and to provide additional information on the amount of other dangerous pollutant emissions into the atmosphere. In estimating the size of these emissions, we used Polish data and data from elsewhere (e.g., emission factors recommended by the UN Economic Commission for Europe) on the typical emission characteristics of specific technological processes, as well as emissions measured at different industrial plants and other pollution sources.

The emissions of major air pollutants in Poland in 1987 are presented in *Table 13.2.* In addition to the actual emissions, E_x, the table includes the so-called equivalent emission, E_e, which is a measure of a pollutant's toxicity compared with SO_2 toxicity. The equivalent emissions may be used as an indicator of the threat posed to the environment by different pollutants and is given by

$$E_e = E_x k_a \ ,$$

in which E_e is the equivalent emissions, E_x is the emissions of pollutant x, and k_a is the toxicity coefficient given by

$$k_a = \frac{D_{SO_2}}{D_x} \ ,$$

where D_{SO_2} is the allowable average annual SO_2 concentration and D_x is the allowable average annual concentration of pollutant x. The allowable concentrations and resulting toxicity coefficients are presented in *Table 13.3.*

Table 13.1. Air pollutants (emission, deposition) measured by the environmental studies and monitoring stations (OBs).

Substance	Emission		Deposition	
	No. of OBs	No. of methods	No. of OBs	No. of methods
Acetylene	–	–	2	1
Acrolein	1	1	1	2
Akrylany	–	–	–	–
Acrylonitrile	–	–	–	–
Organic Aldehyde	–	–	3	3
Methyl Aldehyde	1	1	2	2
Ammonia	5	4	9	7
Anilin	1	1	1	1
Nitrogen	–	–	–	–
Arsenic	–	–	–	–
Benzene	4	4	4	3
Benzopyrene	1	1	1	1
Gasoline	1	1	1	1
Chlorine	7	5	5	4
Ethyl chloride	–	–	–	–
Methyl chloride	–	–	–	–
Vinyl chloride	–	–	–	–
Chlorobenzene	–	–	–	–
Chloronaphthalene	–	–	–	–
Hydrochloric acid	8	7	8	8
Chromium	2	2	3	2
Cyanide	4	4	6	4
Disulfide	5	3	6	5
Sulfur dioxide	40	20	42	16
Phenol	2	2	8	5
Fluorine	9	6	6	7
Formaldehyde	5	3	3	2
Glycol	–	–	–	–
Cadmium	–	–	2	2
Creosol	1	1	–	–
Xylene	8	5	8	5
Sulfuric acid	9	8	7	3
Copper	–	–	2	2
Nitrobenzene	–	–	1	1
Octan vinyl	–	–	1	1
Mineral oil	–	–	–	–
Lead	3	3	5	5
Ozone	–	–	1	1
Suspended particles	35	20	26	20
Silicon	4	4	2	2
Mercury	1	1	–	–
Soot	1	1	–	–
Hydrosulfuric acid	9	7	10	7
Styrene	3	2	2	2
Ethyl oxide	–	–	–	–
Nitric oxide	13	6	1	1
Nitrogen	29	13	25	13
Toluene	7	5	8	6
Trichlorethylene	2	2	2	1
Hydrocarbon aliphatic	–	–	–	–
Hydrocarbon aromatic	1	1	1	1

Sources: Dane dotyczące emisji zanieczyszczeń atmosfery w Polsce w 1987; Wyniki pomiarów imisji wykonanych w 1987 nadesłane przez ośrodki badań i kontroli środowiska.

Table 13.2. Emissions of major air pollutants in Poland, in 1,000 tons per year, in 1987.

Substance	Power network	Industry	Motor vehicles	Dispersed sources	Total	Equivalent emission
Silicon	900.00	1,500.00	–	1,000	3,400.00	4,930
Sulfur dioxide	2,050.00	1,120.00	100.0	930	4,200.00	4,200
Nitrogen (as NO_2)	500.00	460.00	450.0	120	1,530.00	2,200
Nitric oxide	60.00	1,370.00	920.0	850	3,200.00	865
Hydrocarbon aromatic	20.00	150.00	230.0	–	400.00	296
Disulfide	–	20.00	–	–	20.00	168
Hydrosulfuric acid	–	8.00	–	–	8.00	80
Fluorine compounds	0.50	3.50	–	–	4.00	80
Heavy metals:						
Arsenic	0.10	0.60	–	–	0.70	56
Chromium	0.10	1.10	–	–	1.20	96
Cadmium	–	0.20	–	–	0.20	64
Lead	–	3.00	1.5	–	4.50	720
Mercury	0.01	0.02	–	–	0.03	24

Sources: Jaworski, 1988; Nowicki, 1987.

In 1987 the most environmentally injurious pollutants emitted by domestic pollution sources were dust and sulfur dioxide, followed by nitric oxides, heavy metals, and carbon monoxide (*Table 13.2*).

Table 13.4 contains data on the emissions of dust, SO_2, NO_x, and equivalent emission total from stationary sources in different provinces. This table contains no data about pollution caused by motor vehicles because fuel consumption data of motor vehicles were not available.

Figures 13.1 to *13.4* present the distribution of pollutants emitted by stationary sources throughout Poland (shown in a grid of 10 km $\times$ 10 km squares). *Table 13.4* indicates that as much as 20% of the main three pollutants' emissions took place in the Katowice province, that is, on just 2.1% of Poland's total area. Next in order were the Warsaw, Piotrków, Jelenia Gora, and Cracow provinces where these pollutant emissions equaled some 4% to 5% of the national equivalent emissions. As much as half of all SO_2, NO_x, and dust emissions were recorded in nine provinces in southern and central Poland covering 17% of the country's total area. Not only do the maps in *Figures 13.1* to *13.4*

Table 13.3. Maximum concentration of air pollutants in micrograms per cubic meter.

	Protected areas			Specially protected areas			Toxicity
Substance	30 mins.	24 hrs.	Annual average	30 mins.	24 hrs.	Annual average	coeffi-cient
Acetylene	500	–	–	100.00	–	–	–
Acrolein	20	10.00	2.50	10.00	4.00	0.80	12.80
Akrylany	10	–	–	5.00	–	–	–
Akrylonitrile	60	20.00	3.20	20.00	10.00	2.50	10.00
Organic aldehyde	20	10.00	2.50	10.00	5.00	1.30	12.80
Methyl aldehyde	1,000	500.00	130.00	200.00	100.00	25.00	0.25
Ammonia	400	200.00	51.00	100.00	50.00	13.00	0.63
Anilin	50	30.00	10.00	20.00	10.00	2.50	3.20
Nitrogen (as NO_3)	200	100.00	25.00	50.00	30.00	10.00	1.28
Arsenic	10	3.00	0.40	5.00	2.00	0.40	80.00
Benzene	1,000	300.00	43.00	200.00	100.00	25.00	0.74
Benzopyrene	–	0.05	–	–	0.03	–	–
Gasoline	3,000	2,000.00	820.00	2,500.00	750.00	110.00	0.04
Chlorine	100	30.00	4.30	30.00	10.00	1.60	7.44
Ethyl chloride	200	100.00	25.00	50.00	20.00	3.80	1.28
Methyl chloride	200	100.00	25.00	50.00	20.00	3.80	1.28
Vinyl chloride	10	5.00	1.30	10.00	3.00	0.40	24.60
Chlorobenzene	100	–	–	50.00	–	–	–
Chloronaphthalene	50	10.00	1.20	10.00	5.00	1.30	26.70
Hydrochloric acid	200	100.00	25.00	50.00	20.00	3.80	1.28
Chromium	5	2.00	0.40	1.50	0.50	0.08	80.00
Cyanide (as HCN)	20	10.00	2.50	10.00	5.00	1.30	12.80
Disulfide	50	20.00	3.80	15.00	4.50	0.60	8.40
SO_2 in 1990	900	350.00	64.00	250.00	75.00	11.00	0.50
SO_2 in 1991	600	200.00	32.00	250.00	75.00	11.00	1.00
Phenol	20	10.00	2.50	10.00	3.00	0.40	12.80
Fluorine (as F)	30	10.00	1.60	10.00	3.00	0.40	20.00
Formaldehyde	50	20.00	3.80	20.00	10.00	2.50	8.40
Glycol	30	10.00	1.60	10.00	3.00	0.40	20.00
Cadmium	5	1.00	0.10	1.50	0.50	0.08	320.00
Creosol	30	10.00	1.60	10.00	5.00	1.30	20.00
Xylene	300	100.00	16.00	40.00	10.00	1.30	2.00
Sulfuric acid	300	100.00	16.00	150.00	50.00	7.90	20.00
Copper	20	5.00	0.60	6.00	2.00	0.30	53.30
Nitrobenzene	50	30.00	10.00	20.00	10.00	2.50	3.20
Octan vinyl	100	–	–	50.00	–	–	–
Mineral oil	100	–	–	30.00	–	–	–
Lead	–	1.00	0.20	–	0.50	0.10	160.00
Ozone	70	30.00	6.20	30.00	20.00	8.20	5.16
Suspended particles	500	150.00	22.00	150.00	60.00	11.00	1.45
Silicon	300	50.00	8.10	40.00	20.00	3.80	3.95
Mercury (as Hg)	–	0.30	0.04	–	0.10	0.02	800.00
Soot	150	50.00	7.90	50.00	20.00	3.80	4.05
Hydrosulfuric acid	60	20.00	3.20	3.00	3.00	0.50	10.00
Styrene	20	–	–	10.00	–	–	–
Ethyl oxide	100	30.00	4.30	30.00	10.00	1.60	7.44
Nitric oxide	5,000	1,000.00	120.00	3,000.00	500.00	61.00	0.27
Nitrogen (as N_2O_5)	500	150.00	22.00	150.00	50.00	7.90	1.45
Toluene	300	200.00	82.00	100.00	50.00	13.00	0.39
Trichlorethylene	600	300.00	76.00	50.00	10.00	1.20	0.42
Hydrocarbon aliphatic	3,000	2,000.00	820.00	1,000.00	500.00	130.00	0.04
Hydrocarbon aromatic	1,000	300.00	43.00	300.00	100.00	16.00	0.74

Source: Rozporządzenie Rady Ministrów z dnia 30 września 1980.

Table 13.4. Air-pollutant emissions measured in 1987.

	SO_2		NO_x (as NO_2)		Dust		Equivalent emission total	
Province	1,000 t yr^{-1}	%	1,000 t yr^{-1}	%	1,000 t yr^{-1}	%	1,000 t yr^{-1}	%
Stoleczne Warszaw	164.3	3.9	43.7	3.8	198.3	5.8	516.3	4.8
Bialskopodlaskie	11.7	0.3	2.2	0.2	14.9	0.4	36.5	0.3
Bialostockie	37.9	0.9	9.4	0.8	43.9	1.3	115.6	1.1
Bielskie	52.6	1.3	20.5	1.8	103.7	3.1	233.3	2.2
Bydgoskie	100.8	2.4	36.4	3.1	96.0	2.8	293.3	2.7
Chelmskie	17.0	0.4	6.0	0.5	38.9	1.1	82.2	0.8
Ciechanowskie	16.7	0.4	3.4	0.3	21.0	0.6	52.1	0.5
Czestochowskie	50.3	1.2	17.1	1.5	76.4	2.3	186.1	1.7
Elblaskie	21.9	0.5	8.0	0.7	34.0	1.0	82.9	0.8
Gdanskie	107.3	2.6	34.1	2.9	106.2	3.1	311.3	2.9
Gorzowskie	26.3	0.6	8.2	0.7	39.1	1.2	95.0	0.9
Jeleniogorskie	251.2	6.0	21.3	1.8	140.3	4.1	486.2	4.5
Kaliskie	29.4	0.7	7.1	0.6	37.9	1.1	94.7	0.9
Katowickie	950.9	22.6	242.3	22.4	561.3	16.5	2,116.1	19.8
Kieleckie	73.7	1.8	26.7	2.3	72.2	2.1	217.5	2.0
Koninskie	160.1	3.8	24.4	2.1	118.2	3.5	367.5	3.4
Koszalinskie	20.4	0.5	4.4	0.4	27.8	0.8	67.1	0.6
Miejskie Krakow	138.9	3.3	53.0	4.9	151.2	4.5	434.8	4.1
Krosnienskie	16.9	0.4	5.9	0.5	17.2	0.5	50.6	0.5
Legnickie	137.6	3.3	34.4	3.0	38.0	1.1	242.9	2.3
Leszczynskie	21.4	0.5	4.6	0.4	29.6	0.9	71.0	0.7
Lubelskie	80.9	1.9	38.7	3.3	94.1	2.8	274.2	2.6
Lomzynskie	23.2	0.6	5.9	0.5	23.2	0.7	65.5	0.6
Miejskie Lodz	87.8	2.1	13.0	1.1	96.7	2.8	247.4	2.3
Nowosadeckie	19.9	0.5	3.4	0.3	27.6	0.8	65.0	0.6
Olsztynskie	30.3	0.7	6.0	0.5	40.8	1.2	98.3	0.9
Opolskie	96.5	2.3	44.2	3.8	117.2	3.5	331.2	3.1
Ostroleckie	65.2	1.6	41.0	3.5	51.6	1.5	199.9	1.9
Pilskie	16.0	0.4	3.3	0.3	28.4	0.8	62.1	0.6
Piotrkowskie	288.6	6.9	42.2	3.9	75.5	2.2	459.3	4.3
Piockie	113.2	2.7	31.1	2.7	25.8	0.8	195.9	1.8
Poznanskie	45.5	1.1	9.9	0.9	58.3	1.7	144.7	1.3
Prezemyskie	11.2	0.3	3.1	0.3	13.1	0.4	34.7	0.3
Radomskie	150.5	3.6	33.5	3.1	88.4	2.6	327.3	3.1
Rzeszowskie	30.8	0.7	10.3	0.9	30.5	0.9	90.0	0.8
Siedleckie	21.0	0.5	3.7	0.3	29.8	0.9	69.6	0.6
Sieradzkei	20.6	0.5	4.2	0.4	32.0	0.9	73.3	0.7
Skierniewickie	14.7	0.4	3.3	0.3	18.1	0.5	45.8	0.4
Slupskie	14.0	0.3	3.2	0.3	16.9	0.5	43.3	0.4
Suwalskie	19.0	0.5	4.4	0.4	22.3	0.7	58.0	0.5
Szczeinskie	158.9	3.8	38.0	3.3	119.7	3.5	388.3	3.6
Tarnobrzeskie	212.2	5.0	26.0	2.2	83.7	2.5	371.8	3.5
Tarnowskie	39.1	0.9	22.8	2.0	59.0	1.7	158.1	1.5
Torunskie	47.2	1.1	12.3	1.1	44.1	1.3	129.3	1.2
Walbrzyskie	43.9	1.0	13.5	1.2	63.1	1.9	155.2	1.4
Wloclawskie	33.6	0.8	11.1	1.0	32.2	1.0	96.6	0.9
Wroclawskie	80.6	1.9	31.0	2.7	93.7	2.8	262.1	2.4
Zamojskie	15.6	0.4	4.4	0.4	18.2	0.5	48.4	0.5
Zielonogorskie	26.1	0.6	7.5	0.6	29.4	0.9	79.8	0.7
Poland	4,213.4	100.0	1,084.1	100.0	3,399.4	100.0	10,728.0	100.0

Source: Jaworski, 1988.

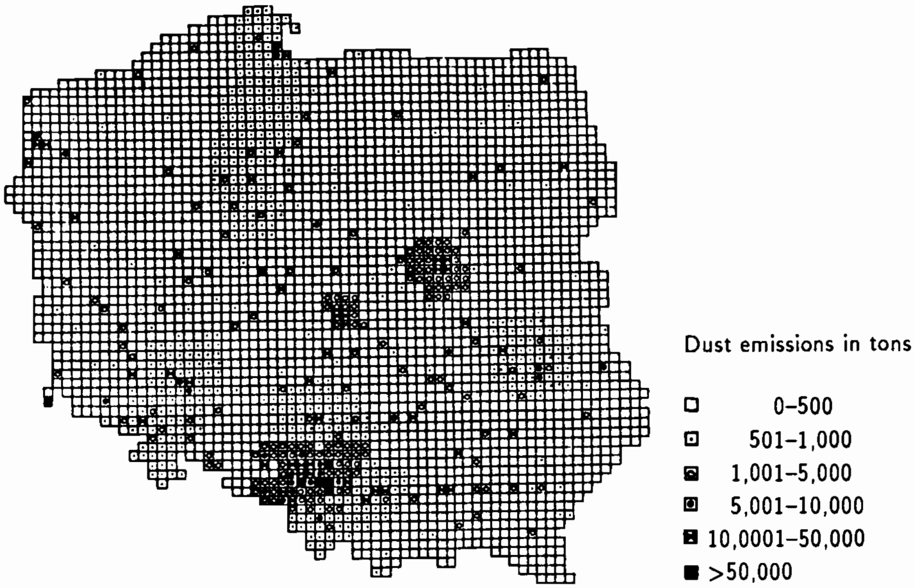

Figure 13.1. Distribution of dust emissions in Poland in 1987, in tons. Each square represents 10 km × 10 km. Source: Jaworski, 1988.

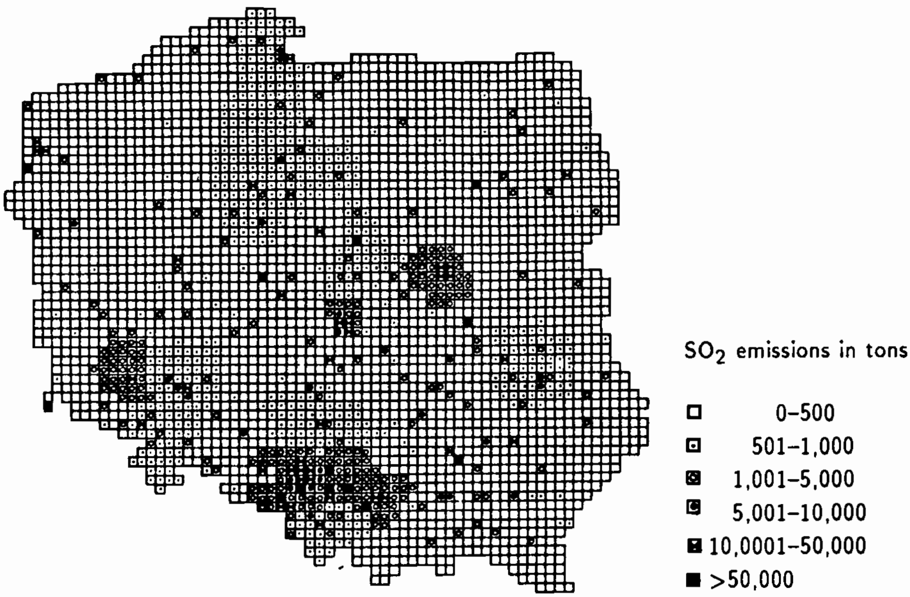

Figure 13.2. Distribution of SO_2 emissions in Poland in 1987, in tons. Source: Jaworski, 1988.

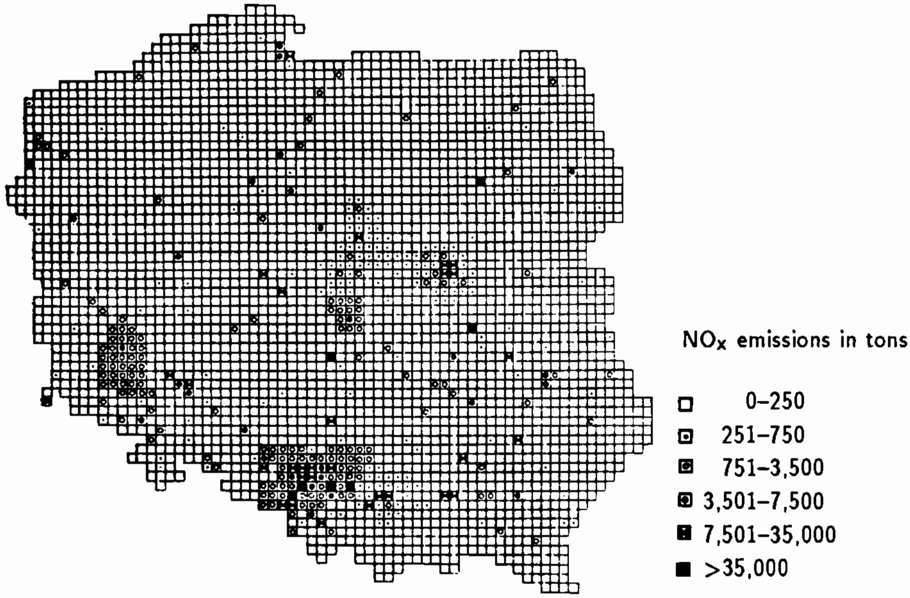

Figure 13.3. Distribution of NO_x emissions in Poland in 1987, in tons. Source: Jaworski, 1988.

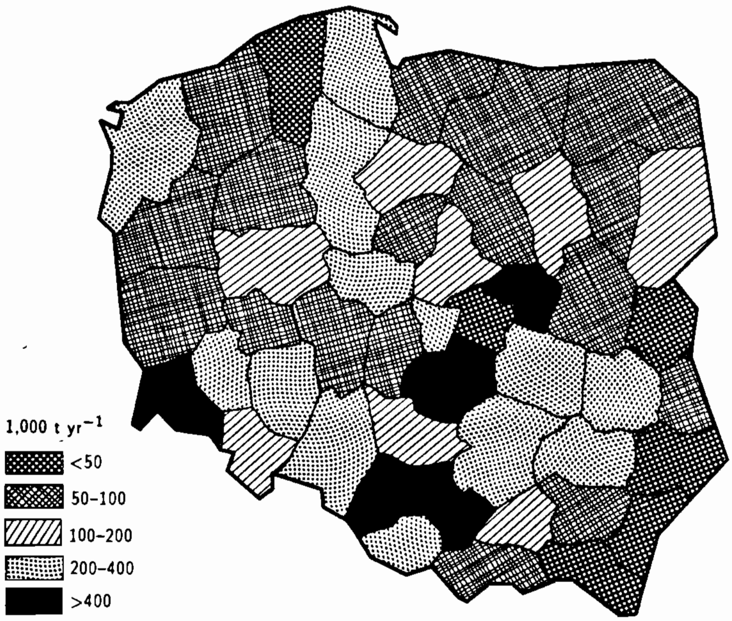

Figure 13.4. Distribution of equivalent emissions in Poland in 1987, in 1,000 tons per year. Source: Nowicki, 1987.

show the locations of strong point sources (such as power plants), they also show where dispersed sources are located. These sources include agricultural and food sectors in the Lublin, Gdansk, Bydgoszcz, and Wroclaw provinces. As can be expected, the pollutants' lowest emissions were recorded in the northern provinces (with the exception of Szczecin and the Vistula valley) and in the eastern provinces and the Carpathians (with the exception of Bielsk Biala). These regions have special tourist and recreational attractions and in the future they should be specially protected.

13.2 Ambient Air Pollution

The need to protect the public and the natural environment from air pollution has led to the designation of two types of areas:

- Protected areas in specific parts of the country, especially in urban/industrial areas.
- Specially protected areas, such as health resorts, national parks, nature reservations, landscape parks, protected forests, and some urban areas with special cultural value.

Table 13.3 lists the maximum allowable concentration of the 54 most common contaminants in these two kinds of protected areas. The main objective of ambient measurements in these areas is to ensure that these limits are not exceeded. Long-term trends in air pollution over large areas are also monitored by background air-quality measurements. In summary, measurements can be differentiated according to their objectives and scale:

- Measurements of the so-called base network, which collects measurements of background air pollution in large areas (national monitoring).
- Measurements taken in urban/industrial areas (urban monitoring).
- Measurements taken at industrial plants and in the surrounding areas (local monitoring).

13.2.1 National monitoring

In 1987 only a few stations in Poland measured background air pollution and took part in international research programs:

- BAPMon (Background Air Pollution Monitoring Network) – a program for monitoring air pollution and climate changes on the global scale (carried out by the UN World Meteorological Organization, WMO).
- GEMS (Global Environmental Monitoring System) and its East European branch GSMOS (Globalnyi System Monitoringa Okhruzayushchey Sredy) – a world program for recording the long-term influence of air pollution on the natural environment (carried out by UNEP).
- GOOS (Global Ozone Observing System) – a world program for monitoring long-term changes in ozone concentration in the atmosphere (carried out by WMO).
- EMEP (European Monitoring and Evaluation Program) – a European program for measuring ambient concentrations and deposition of major pollutants and for using these data to validate mathematical models of transboundary transport of pollutants (carried out by the UN Economic Commission for Europe).
- BMP (Baltic Monitoring Program) – a program for measuring the quantity of air- and water-borne pollutants reaching the Baltic Sea (carried out by the Helsinki Commission, HELCOM).

The following Polish stations participated in these programs in 1987: BAPMon – the Institute of Meteorology and Water Resources' (IMGW) measurement stations in Suwalki and on Mt. Śnieżka; GEMS – the Environmental Protection Institute station in the Puszcza Borecka Forest (Diabla Gora); GOOS – the Polish Academy of Sciences' Geophysics Institute Station at Belsk and an IMGW station at Legionowo; EMEP – the IMGW stations in Suwalki and Jarczewo; and BMP – the IMGW station in Leba (under construction). The location of the stations is shown in *Figure 13.5.*

The average concentration of sulfur compounds (SO_2 and sulfates) and oxidized nitrogen (nitric oxides and nitrates) recorded in Suwalki, Jarczewo, and Diabla Gora are listed in *Table 13.5.* The table shows that the average SO_2 concentration at the background level in eastern and northeastern Poland amounted to 10 micrograms per cubic meter as SO_2. This is about 15% of the allowable SO_2 concentration for protected areas and approximately 90% of the allowable concentration for specially protected areas.

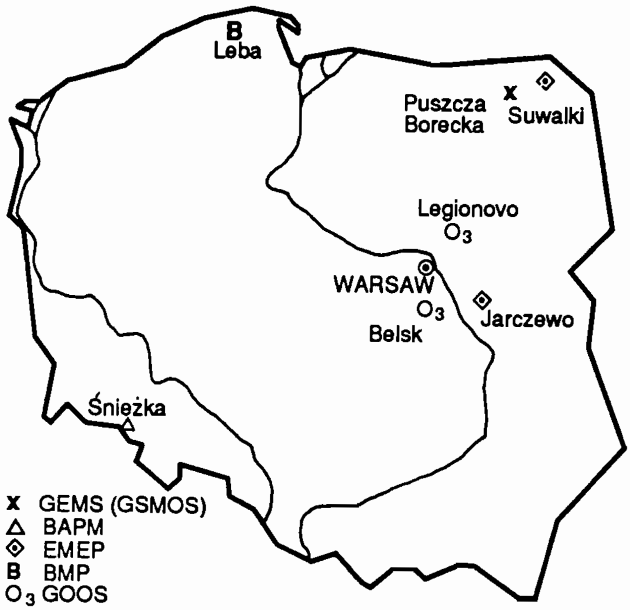

Figure 13.5. Location of national monitoring stations participating in international research programs. Source: Nowicki, 1987.

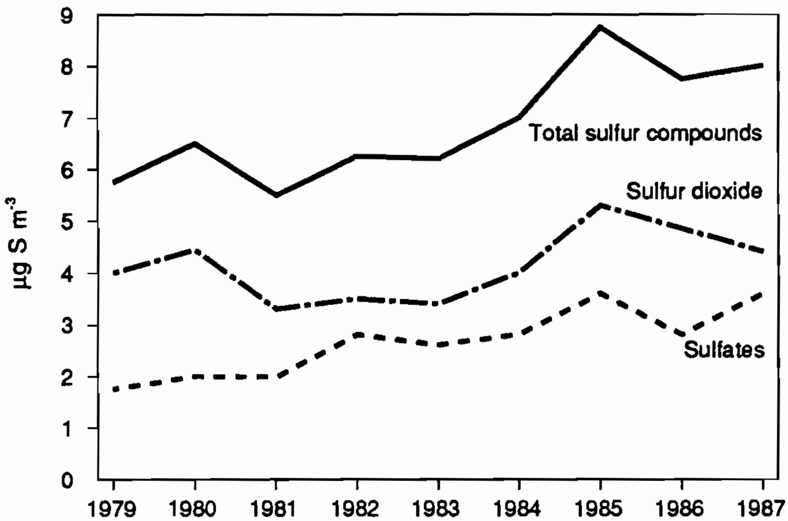

Figure 13.6. Average annual concentration of sulfur compounds from 1979 to 1987 at the EMEP station in Suwalki. Source: Wyniki pomiarów zanieczyszczeń atmosfery uzyskane, 1987.

Table 13.5. Average concentration of sulfur and oxidized nitrogen compounds measured at background stations in 1987.

	μg S m^{-3}			μg N m^{-3}		
Station	SO_2	SO_4^{2-}	$SO_2 + SO_4^{2-}$	NO_2	NO_3^{1-}	$NO_2 + NO_3^{1-}$
Suwalki	4.6	3.5	8.1	3.3	0.7	4.0
Jarczewo	5.2	4.2	9.4	4.6	0.8	5.4
Diabla Gora	3.9	7.3	11.2	6.2	1.3	7.5

Source: Wyniki pomiarów zanieczyszczeń atmosfery uzyskane w 1987 w stacjach tła.

Figure 13.6 illustrates the results of the measurements of average annual SO_2 and sulfate concentrations taken from 1979 to 1987 by the EMEP station in Suwalki. The data indicate that the concentrations of sulfur compounds reached their highest level in 1985. This was also evident in the measurements of the EMEP station at Jarczewo. Unfortunately, a definite cause for this peak has not been identified.

Measurements of background concentrations of nitrogen compounds were not taken in Poland before 1985; therefore their long-term trends are unknown. The 1987 annual average concentration of nitric oxides measured at background stations ranged between 3 and 5 micrograms per cubic meter of nitrogen (*Table 13.5*), which corresponds to 23 to 41 micrograms per cubic meter of N_2O_5. Meanwhile their allowable annual concentrations are 22 micrograms per cubic meter of N_2O_5 in the protected areas and 7.9 micrograms per cubic meter in specially protected areas (see *Table 13.3*). This means that even in the least polluted areas in Poland nitric oxide concentrations greatly exceed allowable limits. It should be noted, however, that the allowable NO_x concentration in Poland is much stricter than the limits set by other countries.

Acid precipitation is the result of the presence of sulfur and nitrogen compounds in the air. The pH value of rain is an indicator of the degree of this acidity. In pure air, precipitation acidity usually equals pH 5.6. When pH drops below 5.0, the precipitation is usually acidic due to anthropogenic pollutants. In 1987, the average pH was 4.42 in Suwalki, 4.36 at Jarczewo, and 4.26 at Diabla Gora. On Mt. Śnieżka the level of precipitation acidity was much higher; the average annual pH was 3.8, which is among the lowest pH values measured in Europe.

Figure 13.7(a) illustrates the results of long-term measurements of precipitation acidity taken at Polish background stations, and *Figure*

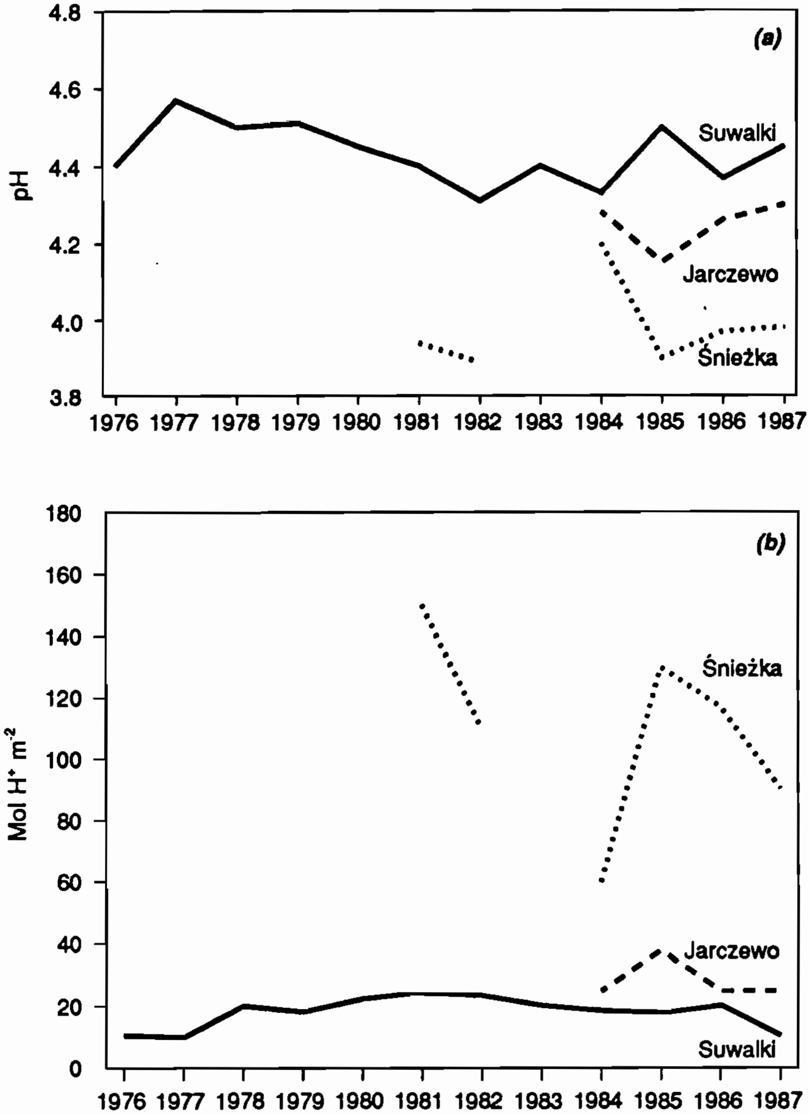

Figure 13.7. (*a*) Average annual pH in precipitation and (*b*) average annual amount of acid mist deposited to soils at IMGW stations. Source: Hryniewicz and Przybylska, 1988a, 1988b.

13.7(b) displays the annual quantity of acid deposition per square meter. The latter measure is the best indicator of the substances which acidify soil and water because it takes into account not only the level of acidity but also its annual flux.

In eastern and northeastern Poland the annual quantity of acid in precipitation amounted to 10 to 30 mol H^+ per square meter [*Figure 13.7(b)*]. This means that 1 gram of sulfuric acid fell on one square meter over one year. On Mt. Śnieżka the corresponding figure was several times higher and amounted to 100 to 150 mol H^+ per square meter. The main reason for this was the across-the-border transport of sulfur and nitrogen compounds from Germany and the CSFR and emissions by the Turow power station. Soil acidification was considered to be the main reason for the dying forests on the border between the CSFR and Germany in the Sudety.

Another important anthropogenic pollutant of the troposphere is ozone, which is generated by complex photochemical reactions involving nitric oxides. This compound at the same time provides a protective layer in the stratosphere against ultraviolet radiation, which has a lethal effect on biological life. It is therefore necessary to maintain high concentrations of ozone in the upper layers of the atmosphere while ensuring that this concentration is as low as possible near the earth's surface.

The vertical profile of ozone concentration has been measured at the PAN station at Belsk for 25 years. It was discovered during this period that ozone concentration in the troposphere showed a statistically significant growing trend of 0.5% per annum, while in the stratosphere it consistently decreased by 0.1% per annum. The overall ozone content in the atmosphere did not change during these 25 years.

The level of ozone concentration varies significantly during the year. In Poland's geographical latitude this concentration is the highest in the spring and the lowest in the autumn. *Figure 13.8* illustrates ozone's average monthly concentration in the atmosphere recorded at the Belsk station in 1987.

Apart from the stations taking background measurements within the framework of international programs, the Forestry Institute has a well-developed system of measuring pollutants concentrations in forests (so-called technical monitoring). In 1987, measurements of dust, SO_2, and NO_x (using the contact method) and fluorine compounds in dust

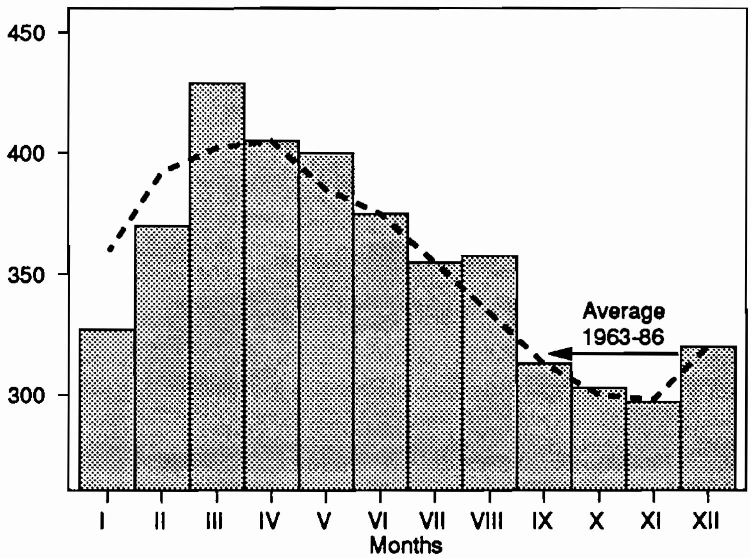

Figure 13.8. Average monthly ozone concentrations measured at the PAN station at Belsk in 1987. Source: Bielawski on the basis of PAN Geophysics Institute data.

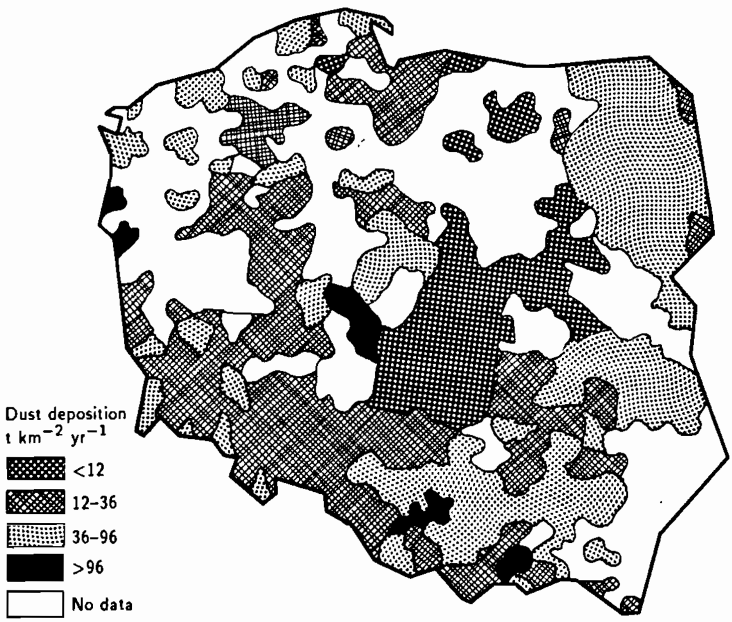

Figure 13.9. Dust deposition to Polish forests in 1987, in tons per square kilometer per year. Source: Wawrzoniak, 1988.

(in certain regions) were taken within the framework of this system at 1,975 sites throughout the country.

Figures 13.9 to *13.11* illustrate the distribution of dust deposition and SO_2 and NO_x concentration in Poland in the winter (October 1987 to April 1988). The contact method used for these data measures only dry deposition of these substances; therefore, these data cannot be compared with allowable concentration limits presented in *Table 13.3.*

Both the number of stations where the measurements were taken and the type of measurement programs used were seriously insufficient for meeting Poland's international commitment to monitoring long-term changes in background air pollution in the country's climatic zones. For this reason, no regional interpretation of results recorded by these stations is possible. It is, therefore, particularly urgent to develop a network of national monitoring stations together with several well-equipped analytical laboratories.

13.2.2 Urban monitoring

Air-pollution measurements in urban and industrial areas are taken by sanitary-epidemic prevention stations (S-E) and environmental studies and monitoring stations (OBs). The types of measurements taken by these stations in 1987 are listed in *Table 13.6*. The most frequent measurements were of dust deposition (approximately 6,000 measurement points throughout the country) and average daily sulfur dioxide concentrations (about 1,000 measurement points). Other frequently taken measurements included those of suspended dust (750 measurement points) and nitric oxides (512 average daily concentration measurement points). The concentrations of other pollutants injurious on the local scale were monitored at several points in different parts of the country. The results of these measurements are presented in *Table 13.7*.

It is not worthwhile to compare and interpret the results obtained at the S-E and OB stations in 1987. Different, and frequently incompatible, methods were employed to take these measurements. This has led to inaccuracies in collecting and evaluating samples, and in interpreting the results. As of yet, there are no standards in Poland concerning the number and location of measurement points or their representativeness for a given region. Nor are there Polish regulations for analyzing most pollutants (*Table 13.1*). Nevertheless, an effort has been made to compare

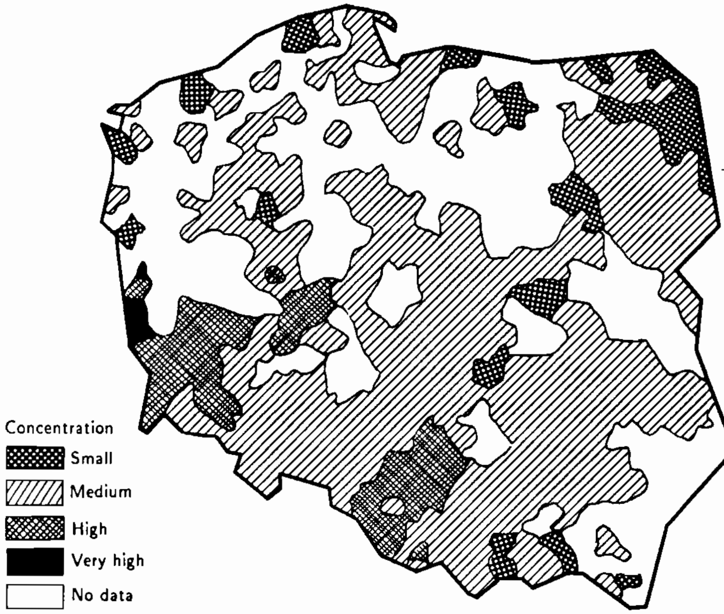

Figure 13.10. SO_2 concentrations measured in Polish forests in 1987, according to Forestry Institute data. Source: Wawrzoniak, 1988.

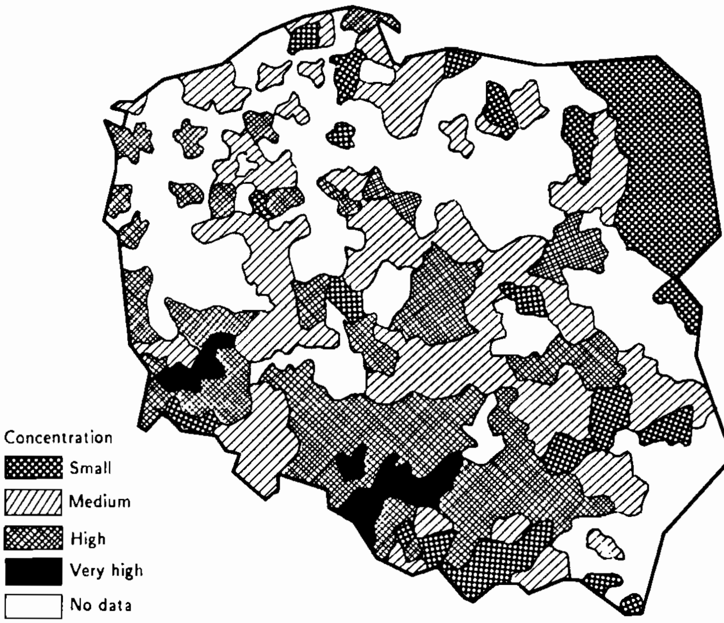

Figure 13.11. Nitric oxide concentrations measured in Polish forests. Source: Wawrzoniak, 1988.

Table 13.6. Measurements taken in 1987 by sanitary-epidemic prevention stations (S-E) and environmental studies and monitoring stations (OB).

		No. of measuring stations					
	Measured	Precipitation	Suspended dust	SO_2	NO_x	Other pollutants	Index method
Province	by	dust	S_{24}/S_{30}	S_{24}/S_{30}	S_{24}/S_{30}	Type and no. of stations	Type and no. of stations
Warszawskie	S-E	163	12/–	18/–	3/–	–	–
	OB	–	172/–	182/–	87/–	Xylen, toluene, HCl/·	–
Bialskopodlaskie	S-E	19	4/–	2/–	1/–	–	–
	OB	–	30-min. single measurement			–	–
Białostockie	S-E	36	5/–	5/–	–	Pb/5	SO_2/36
	OB	86	1/–	–	–	–	–
Bielskie	S-E	154	5/–	5/–	5/–	Pb/5, F_2/2, BaP/3	SO_2/156, NO_x/156,
	OB	18	–	–	–	–	SO_2/10
Bydgoskie	S-E	135	6/–	8/–	8/–	Pb/6, Cl/1, F_2/3, phenol/3, formaldehyde/3	SO_2/73, NO_x/·
	OB	–	30-min. single measurement in 19 places			12 substances 30-min. single measurement	–
Chełmskie	S-E	44	3/–	3/–	1/–	–	–
	OB	–	–/11	–/7	–/7	–	–
Ciechanowskie	S-E	26	6/–	6/–	2/–	–	–
	OB	19	24-hour single measurement			–	–
Częstochowskie	S-E	134	3/–	102/–	88/–	–	SO_2/125, NO_x/125
	OB	49	5/–	3/–	3/–	Phenol/3	SO_2/29
Elbląskie	S-E	46	5/–	5/–	3/–	–	SO_2/94, NO_x/94
	OB	–	–	–	–	–	–
Gdańskie	S-E	160	14/–	14/–	14/–	F_2/2	–
	OB	63	15/–	11/–	15/–	NH_3/2, H_2S/2	–
Gorzowskie	S-E	96	7/–	6/–	5/–	F_2/2, formaldehyde/1	SO_2/5
	OB	–	–/3	–	–	–	–
Jeleniogórskie	S-E	136	–/16	–/35	–/23	F_2/15, C_2/5, H_2S/5, H_2SO_4/23, formaldehyde/4	–
	OB	–	3/–	12/–	3/–	C_2/2, H_2S/2, O_3/1	–

Table 13.6. Continued.

		No. of measuring stations					
	Measured	Precipitation	Suspended dust	SO_2	NO_x	Other pollutants	Index method
Province	by	dust	S_{24}/S_{30}	S_{24}/S_{30}	S_{24}/S_{30}	Type and no. of stations	Type and no. of stations
Kaliskie	S-E	88	4/–	10/–	6/–	Formaldehyde	–
	OB	–	–	–/33	–/23	–	–
Katowickie	S-E	717	18/–	21/–	21/–	NH_3, phenol, F_2, Pb, BaP, perylene, at 21 stations	–
	OB	–	–	–	–	–	–
Kieleckie	S-E	164	10/–	9/–	3/–	Heavy metals/9	–
	OB	–	–	–	–	–	–
Konińskie	S-E	82	3/–	10/–	–	F_2/9	–
	OB	44	–	–/13	–	F_2/·	–
Koszalinskie	S-E	28	2/–	4/–	–	–	–
	OB	n.a.	n.a.	n.a.	n.a.	–	–
Krakowskie	S-E	58	26/–	26/–	1/–	NH_3/24, F_2/29, Pb/4	–
	OB	56	1/–	1/2	1/2	F_2/15	–
Krośnieńskie	S-E	82	19/–	19/–	18/–	F_2/18, heavy metals/19, tar substances/19	–
	OB	–	13/–	9/–	5/–	–	–
Legnickie	S-E	192	7/–	14/–	10/–	H_2SO_4/14, F_2/6, C_2/4, formaldehyde/1, phenol/1, CO/1	–
	OB	–	12/–	12/–	12/–	–	–
Leszczyńskie	S-E	93	6/–	4/–	3/–	Heavy metals/6	–
	OB	–	2/–	2/–	–	–	–
Lubelskie	S-E	57	4/–	4/–	–/·	NH_3/·	–
	OB	28	16/–	21/–	14/–	CO/14	–
Łomżyńskie	S-E	14	2/–	2/–	–	–	–
	OB	–	–	–	–	–	–
Łódzkie	S-E	169	27/–	27/–	6/–	Heavy metals/3, BaP/3, aldehyde/5	–
	OB	138	11/–	11/–	6/–	HCl/6	–

Table 13.6. Continued.

Province	Measured by	No. of measuring stations: Precipitation dust	Suspended dust S_{24}/S_{30}	SO_2 S_{24}/S_{30}	NO_x S_{24}/S_{30}	Other pollutants: Type and no. of stations	Index method: Type and no. of stations
Nowosądeckie	S-E	21	9/–	9/–	–	–	–
	OB	–	7/–	7/–	–	–	–
Olsztyńskie	S-E	75	6/–	6/–	6/–	–	–
	OB	–	Single measurement			–	–
Opolskie	S-E	194	10/–	4/–	1/–	Phenol/3, formaldehyde/1	SO_2/71
	OB	–	24/–	33/–	11/–	NH_3/1, phenol/1	–
Ostrołęckie	S-E	44	7/–	7/–	3/–	F_2/5, Pb/6	–
	OB	69	30-min. single measurement			–	–
Pilskie	S-E	118	2/–	–/9	–/7	–	–
	OB	37	–	–/7	–	Formaldehyde/4	–
Piotrkowskie	S-E	112	3/–	6/–	–/2	C_2/10, H_2S/10	SO_2/29
	OB	–	60/–	67/–	–	HCl/. H_2/. C_2/.	–
Płockie	S-E	37	14/–	12/–	5/–	Phenol/4, formaldehyde/1	–
	OB	–	–	3/–	8/–	Phenol/8, H_2S/3	–
Poznańskie	S-E	205	6/–	11/–	1/–	H_2S/1, heavy metals/2	SO_2/66
	OB	–	30-min. single measurement			–	–
Przemyskie	S-E	66	7/–	7/–	3/–	Pb/7	–
	OB	–	–	12/–	12/–	–	–
Radomskie	S-E	93	3/–	4/–	–	–	–
	OB	–	Single measurement			–	–
Rzeszowskie	S-E	23	11/–	11/–	9/–	F_2/4, heavy metals/11	–
	OB	50	–	50/–	–	–	–
Siedleckie	S-E	34	13/–	13/–	4/–	–	–
	OB	–	–	50/–	50/–	–	–
Sieradzkie	S-E	93	–	–	–/8	–	NO_x/88
	OB	–	Single measurement			–	–
Skierniewickie	S-E	112	–/2	–/5	–/5	–	SO_2/112
	OB	9	3/–	3/–	–	–	–

Table 13.6. Continued.

Province	Measured by	No. of measuring stations: Precipitation dust	Suspended dust S_{24}/S_{30}	SO_2 S_{24}/S_{30}	NO_x S_{24}/S_{30}	Other pollutants: Type and no. of stations	Index method: Type and no. of stations
Słupskie	S-E	40	10/–	8/–	4/–	Tar substances/1	SO_2/51, NO_x/35
	OB	57	30-min. single measurement			–	–
Suwalskie	S-E	8	1/–	1/–	–	–	–
	OB	25	3/–	3/–	–	–	–
Szczecińskie	S-E	89	2/–	4/–	4/–	–	–
	OB	–	–	13/–	4/–	F_2/9, NH_3/9	–
Tarnobrzeskie	S-E	66	8/–	8/–	7/–	F_2/1, H_2S/7, C_2/4	–
	OB	–	4/–	3/–	1/–	F_2/3, H_2S/1	–
Tarnowskie	S-E	43	10/–	–/15	–/11	F_2/1, phenol/1, CL/1	
	OB	–	–	1/–	–	–	–
Toruńskie	S-E	144	3/–	3/–	3/–	–	SO_2/83
	OB	–	–/3	–/8	–/3	SO_3/3, methanol/6	–
Wałbrzyskie	S-E	125	11/–	–/29	–/31	F_2/3, C_2/2, H_2S/2, NH_3/1, CO/1, formaldehyde/24	–
	OB	–	2/–	2/–	2/–	H_2SO_4/1	–
Włocławskie	S-E	152	10/–	12/–	12/–	HCl/5, H_2S/3, Cl/5, NH_3/11 phenol/6, formaldehyde/12	SO_2/83
	OB	20	–	8/–	8/–	NH_3/4, phenol/1, HCl/1, H_2S/1	–
Wrocławskie	S-E	249	50/–	40/–	12/7	18 substances	–
	OB	33	30-min. single measurement			–	–
Zamojskie	S-E	45	2/–	2/–	1/–	–	–
	OB	39	2/–	2/13	–/13	–	–
Zielonogórskie	S-E	15	2/–	2/–	–/2	–	–
	OB	10	–	–	–	–	–
Total		5,944	754/25	1,015/176	512/136		
of which:	S-E	5,094	398/8	494/93	270/88		
	OB	850	356/17	521/83	242/48		

Table 13.7. Other air pollutants measured in 1987 by sanitary-epidemic prevention stations (S-E) and environmental studies and monitoring stations.

Substance	No. of provinces	No. of measuring stations	No. of measuring[a] stations recording values higher than D_x
Aldehyde	1	5	5
Methyl alcohol	1	6	–
Ammonia	8	84	36
Benzopyrene	4	25	25
Chlorine	3	7	1
Hydrochloric acid	4	34	22
Cyanide	1	30	–
Disulfide	5	26	26
Phenol	12	66	35
Fluorine (as F_2)	17	138	68
Formaldehyde	13	133	67
Xylene	1	40	40
Sulfuric acid	4	69	58
Heavy metals (excl. Pb)	13	188	5
Lead	17	106	65
Ozone	1	1	1
Perylene	1	18	–
Hydrosulfuric acid	7	37	20
Nitric oxide	3	30	16
Toluene	1	40	9
Trichlorethylene	1	8	–

[a] D_x = allowable average annual concentration of pollutant x.

the data available. *Tables 13.8* to *13.10* contain a complete list of measurement points and average annual concentration levels of suspended dust, SO_2, and NO_x; *Figures 13.12* to *13.15* illustrate the distribution of dust, suspended dust, SO_2, and NO_x deposition throughout Poland. In these maps, the average concentrations are simply the average of all measurement points in the given square.

The data presented in *Figures 13.9* and *13.12* indicate that there is no relationship between the magnitude of dust deposition, the distribution of dust emissions (*Figure 13.1*), and the distribution of suspended dust concentration (*Figure 13.13*). Nevertheless, dust deposition should be most strongly dependent on dust emission areas. Furthermore, in 1987 the magnitude of dust deposition was greater than the allowable annual limit (250 tons per square kilometers per year) at only 40% of the measurement points, and in almost 50% of the measurement points it was below 100 tons per square kilometer per year. This leads to the completely wrong interpretation that the emission of dust from burning and industrial processes is a marginal problem in Poland. Meanwhile, the concentration of suspended dust was above the allowable limits at 97% of the measurement points, and exceeded the allowable limit by more than a factor of five at 37% of the points (*Table 13.8*, *Figure 13.13*). This indicates that the level of deposited dust is not a good indicator of air pollution, and that continuing these measurements on such a scale serves no purpose. This is especially so considering that the total annual cost of these measurements (spring 1989 prices) was 1 billion zlotys. It seems necessary, therefore, to modify the methods used for measuring the magnitude of dust deposition and its chemical composition.

Another pollutant concentration which greatly exceeded the allowable limit was nitric oxide. In 1987, the limit was exceeded at 93% of the measurement stations, and in 20% of the stations it was exceeded by more than a factor of five. It was interesting to see that in addition to the big urban and industrial centers (Upper Silesia, Warsaw, Cracow, and Lodz), the NO_x concentration seriously exceeded limits in some small towns. Therefore it is necessary to pay more attention to reducing NO_x emissions from vehicles, households, and industrial furnaces.

Interpreting the results of NO_x concentration measurements is difficult because of the inaccuracies of these measurements. By comparing the absolute values of NO_x and SO_2 concentration, we can see that in many cases the concentration of nitric oxides is higher than sulfur dioxide concentrations. However, in stationary burning processes, the ratio of NO_x to SO_2 emissions is not higher than 1:3 which would imply that auto traffic in small towns must have been responsible for such a large increase in annual NO_x concentrations. Yet, it is improbable that the increase in vehicle usage caused such a large increase in NO_x emissions. Consequently, it is very important to examine the accuracy of these measurement data.

Contrary to that of nitric oxides, the average annual concentration of SO_2 was higher than the allowable limit in just 24% of the measurement points in 1987. To a large extent this resulted from the very high allowable annual limit which in Poland amounts to 64 micrograms per cubic meter. Had the allowable concentration been 32 micrograms per cubic meter (the limit introduced in Poland in 1991) it would have been surpassed in 70% of the measurement stations, and in 4% of the stations it would have been surpassed by more than a factor of five. These data confirm the conventional wisdom that Poland is subject to a very high degree of sulfur pollution.

The results of ambient measurements of the main air pollutants (*Tables 13.8* to *13.10*), and particular pollutants posing local threats (*Table 13.7*), reveal an alarming degree of air pollution not only in the large urban and industrial centers but also in many small towns. It should be re-emphasized, however, that the data contain serious inaccuracies which reduce their credibility. The main reasons for these inaccuracies are the following:

- Inconsistent implementation of measurement programs and selection of analytical methods.
- Lack of a national system of testing the quality of measurements and equipment, and inability to confirm data from analytical laboratories.
- Lack of high-standard measurement devices (automatic analyzers and other analytic equipment) and chemical agents and filters.
- Lack of a uniform recording system to process and publish results.

The random choice of measurement methods is illustrated by the number of methods employed by individual OB stations in different provinces to determine the concentration of major air pollutants (*Table 13.1*). It shows, for instance, that 20 different methods were used to determine the concentration of suspended dust, 16 methods to determine SO_2 concentration, and 13 methods to study NO_x concentration. In this situation, comparing the results obtained in different areas becomes unrealistic. At present, however, the Environmental Protection Institute is drafting a package of regulations and standards for monitoring urban air quality. Also, data banks of air-pollution emission data from the provinces are being organized. Only the introduction of these regulations and standards throughout Poland can bring about a major improvement in the qualitative assessment of the state of air pollution in Poland.

Table 13.8. Average annual concentration of suspended dust in 1987. Allowable average annual concentration (D_a) in the protected regions equals 22 μg m^{-3}.

Province/ City	Measure-ments made by	No. of measuring stations	Average concentration (μg m^{-3})
Warszawskie			
Warszawa:			
Śródmieście	OB	8	238
Mokotów	OB	5	335
Praga Płn.	OB	24	152
Wola	OB	28	258
Żoliborz	OB	23	119
Grodzisk Mazowiecki	OB	26	263
Góra Kalwaria	OB	7	251
Konstancin	OB	6	188
Nowy Dwór Mazowiecki	OB	15	260
Otwock	S-E	1	60
Ożarów	OB	6	148
Piaseczno	S-E	1	55
Pruszków	S-E	1	60
	OB	18	281
Wołomin	S-E	1	65
	OB	6	180
Białostockie			
Białystock	S-E	4	30
Hajnówka	S-E	1	32
Bielskie			
Bielsko-Biała	S-E	2	$> D_a$
Oświęcim	S-E	1	$> D_a$
Szczyrk	S-E	1	$> D_a$
Bydgoskie			
Bydgoszcz	S-E	4	220
Inowrocław	S-E	1	330
Koronowo	S-E	1	80
Chełmskie			
Chełm	S-E	2	55
Włodawa	S-E	1	50
Ciechanowskie			
Ciechanów	S-E	1	$> D_a$
Działdowo	S-E	1	$> D_a$
Mława	S-E	1	$> D_a$
Płońsk	S-E	1	$> 0.5\ D_a$
Pułtusk	S-E	1	$> D_a$
Żuromin	S-E	1	$> D_a$
Częstochowskie			
Częstochowa	S-E	3	48
	OB	3	55
Rudniki	OB	1	283
Rejon Miasteczka Śląskiego	OB	1	63
Elbląskie			
Elbląg	S-E	3	32

Table 13.8. Continued.

Province/ City	Measure-ments made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Frombork	S-E	1	4
Kwidzyń	S-E	1	26
Gdańskie			
Gdańsk:			
Śródmieście	S-E	1	102
Nowy Port	S-E	1	67
Oliwa	S-E	1	36
Wrzeszcz	S-E	1	23
Gdynia	S-E	4	52
Kościerzyna	S-E	1	142
Puck	S-E	1	178
Sopot	S-E	1	61
Starogard Gdański	S-E	1	116
Tczew	S-E	1	115
Wejherowo	S-E	1	71
Jeleniogórskie			
Jelenia Góra	S-E	1	$> D_a$
Cieplice	OB	1	107
Bolesławiec	S-E	1	$> D_a$
Lwówek Śląski	S-E	1	$> D_a$
Rozdroże Izerskie	OB	1	59
Worek Żytawski	OB	1	75
Zgorzelec	S-E	1	$> D_a$
Kaliskie			
Kalisz	S-E	2	$> D_a$
Ostrów Wielkopolski	S-E	1	$> D_a$
Skalmierzyce	S-E	1	$> D_a$
Katowickie			
Katowice	S-E	2	221
Chorzów	S-E	1	289
Chrzanów	S-E	1	209
Dąbrowa Górnicza	S-E	2	218
Łaziska	S-E	1	189
Mysłowice	S-E	1	222
Olkusz	S-E	1	228
Pszczyna	S-E	1	154
Ruda Śląska	S-E	1	312
Tarnowskie Góry	S-E	1	164
Toszek	S-E	1	135
Wodzisław	S-E	1	227
Zabrze	S-E	1	172
Zawiercie	S-E	1	221
Rudnik	S-E	1	116
Zebrzydowice	S-E	1	152
Kieleckie			
Kielce	S-E	3	$> D_a$
Busko Zdrój	S-E	1	$> D_a$
Jędrzejów	S-E	1	$> 0.5\ D_a$
Końskie	S-E	1	$> D_a$

Table 13.8. Continued.

Province/ City	Measure-ments made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Ostrowiec	S-E	1	$> D_a$
Skarżysko	S-E	1	$> D_a$
Starachowice	S-E	1	$> D_a$
Konińskie			
Konin	S-E	2	24
Turek	S-E	1	44
Koszalinskie			
Koszalin	S-E	1	121
Białogard	S-E	1	115
Krakowskie			
Kraków:			
Śródmieście	S-E	5	110
	OB	1	41
Krowodrza	S-E	4	78
Nowa Huta	S-E	3	67
Podgórze	S-E	3	99
Ojców	S-E	1	37
Myślenice	S-E	1	33
Słomniki	S-E	1	140
Sułkowice	S-E	1	41
Swoszowice	S-E	1	46
Zabierzów	S-E	1	54
Krośnieńskie			
Krosno	S-E	5	22
	OB	5	19
Jasło	S-E	4	42
	OB	6	31
Iwonicz Zdrój	S-E	1	12
Rymanów	S-E	1	16
Komańcza	OB	1	7
Lesko	S-E	1	36
Sanok	S-E	6	42
Solina	OB	1	4
Tarnowiec	S-E	1	26
Legnickie			
Legnica	S-E	1	470
	OB	4	95
Głogów	S-E	1	144
	OB	3	90
Jawor	S-E	1	148
Jaczów	OB	1	77
Krzepów	OB	1	99
Lubin	S-E	1	172
Moszowice	OB	1	67
Prochowice	S-E	1	133
Serby	OB	1	111
Szczyglice	OB	1	96
Zlótoryja	S-E	1	85
Żukowice	S-E	1	191

Table 13.8. Continued.

Province/ City	Measure-ments made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Leszczyńskie			
Leszno	S-E	2	$> D_a$
	OB	2	49
Gostyń	S-E	1	$> D_a$
Góra	S-E	1	$> D_a$
Kościerz	S-E	1	$> D_a$
Rydzyna	S-E	1	$> D_a$
Lubelskie			
Lublin	S-E	3	$> D_a$
Nałęczów	S-E	1	$> D_a$
Bychawa	OB	2	395
Kraśnik	OB	3	335
Lubartów	OB	3	312
Łączna	OB	2	335
Opole Lubelskie	OB	2	395
Poniatowa	OB	2	286
Trawniki	OB	2	442
Łomżyńskie			
Łomża	S-E	1	36
Nowogród	S-E	1	8
Łódzkie			
Łódź:			
Śródmieście	S-E	4	87
Bałuty	S-E	5	61
Górna	S-E	4	66
Polesie	S-E	3	57
Widzew	S-E	4	51
Aleksandrów	S-E	1	44
Andrespol	S-E	1	50
Głowno	S-E	1	37
Pabianice	S-E	1	91
	OB	3	74
Rzgów	S-E	1	47
Stryków	S-E	1	59
Zgierz	OB	8	54
Nowosądeckie			
Nowy Sącz	S-E	2	96
Grybów	S-E	1	25
Krynica	S-E	2	35
Muszyna	S-E	1	69
Nowy Targ	OB	3	72
Piwniczna	S-E	1	45
Stary Sącz	S-E	1	79
Zakopane	OB	4	58
Żegiestów	S-E	1	45
Olsztyńskie			
Olsztyn	S-E	2	52
Biskupiec	S-E	1	102
Iława	S-E	1	119
Mrągowo	S-E	1	67
Szczytno	S-E	1	47

Table 13.8. Continued.

Province/ City	Measurements made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Opolskie			
Opole	OB	3	162
	S-E	3	36
Brzeg	S-E	1	57
Góra Św. Anny	S-E	1	38
Grodków	S-E	1	50
Kędzierzyn–Koźle	S-E	2	88
	OB	19	54
Ozimek	S-E	1	54
Raszowa	S-E	1	48
Zawadzkie	OB	2	39
Ostrołęckie			
Ostrołęka	S-E	2	29
Brok	S-E	1	10
Maków Mazowiecki	S-E	1	39
Ostrów Mazowiecki	S-E	1	39
Przasnysz	S-E	1	35
Wyszków	S-E	1	57
Pilskie			
Piła	S-E	1	57
Czarnków	S-E	1	35
Piotrkowskie			
Piotrków Trybunalski	S-E	1	55
	OB	10	33
Bełchatów	OB	1	46
Koluszki	OB	3	2
Niewiadów	OB	1	17
Opoczno	OB	13	10
	S-E	1	82
Radomsko	OB	19	40
Tomaszów Mazowiecki	OB	13	35
	S-E	1	70
Płockie			
Płock	S-E	8	28
Gostynin	S-E	1	29
Sierpc	S-E	1	54
Kutno	S-E	4	37
Poznańskie			
Poznań	S-E	4	85
Gniezno	S-E	1	86
Śrem	S-E	1	26
Przemyskie			
Przemyśl	S-E	2	52
Jarosław	S-E	1	49
Lubaczów	S-E	1	41
Przeworsk	S-E	1	53
Radymno	S-E	1	37
Radomskie			
Kozienice	S-E	1	$> 0.5\ D_a$
Przysucha	S-E	1	$> 0.5\ D_a$
Skaryszew	S-E	1	$> 0.5\ D_a$

Table 13.8. Continued.

Province/ City	Measure- ments made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Rzeszowskie			
Rzeszów	S-E	8	50
Glogów Małopolski	S-E	1	35
Ropczyce	S-E	1	39
Strzyżów	S-E	1	60
Siedleckie			
Siedlce	S-E	6	53
Mińsk Mazowiecki	S-E	3	52
Łuków	S-E	1	59
Kałuszyn	S-E	1	45
Sokołów	S-E	1	25
Węgrów	S-E	1	33
Skierniewickie			
Skierniewice	S-E	2	43
Żyrardów	OB	3	15
Słupskie			
Słupsk	S-E	5	97
Człuchów	S-E	1	25
Miastko	S-E	1	45
Lębork	S-E	1	21
Sławno	S-E	1	46
Ustka	S-E	1	63
Suwalskie			
Suwałki	S-E	1	52
	OB	2	65
Szczecińskie			
Szczecin	S-E	1	161
Gryfice	S-E	1	339
Tarnobrzeskie			
Tarnobrzeg	S-E	1	48
Baranów	S-E	1	45
Grębów	S-E	1	60
Janów Lubelski	S-E	1	102
Nowa Dęba	OB	1	11
Sandomierz	S-E	2	39
Stalowa Wola	S-E	1	23
	OB	1	12
Machów	OB	2	26
Staszów	S-E	1	44
Tarnowskie			
Tarnów	S-E	4	39
Bochnia	S-E	1	37
Brzesko	S-E	1	36
Dąbrowa Tarnowska	S-E	1	57
Dębica	S-E	1	65
Niedomice	S-E	1	20
Żabno	S-E	1	34
Toruńskie			
Toruń	S-E	1	230

Table 13.8. Continued.

Province/ City	Measure-ments made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Grudziądz	S-E	1	91
Kowalewo	S-E	1	72
Wałbrzyskie			
Wałbrzych	S-E	4	227
	OB	1	190
Szczawno Zdrój	OB	1	270
Jedlina Zdrój	S-E	1	202
Dzierżoniów	S-E	1	157
Kłodzko	S-E	1	70
Nowa Ruda	S-E	1	318
Pieszyce	S-E	1	52
Świdnica	S-E	1	131
Ząbkowice	S-E	1	291
Włocławskie			
Włocławek	S-E	4	165
	OB	4	203
Aleksandrów	S-E	2	120
Ciechocinek	S-E	2	120
Lipno	S-E	1	500
Wieniec Zdrój	S-E	1	140
Wrocławskie			
Wrocław:			
Śródmieście	S-E	4	113
Stare Miasto	S-E	3	71
Fabryczna	S-E	7	63
Krzyki	S-E	7	66
Psie Pole	S-E	7	78
Brzeg	S-E	1	61
Oborniki	S-E	1	76
Oleśnica	S-E	2	142
Oława	S-E	5	59
Milicz	S-E	3	42
Strzelin	S-E	1	34
Środa Śląska	S-E	3	133
Wołów	S-E	2	51
Trzebnica	S-E	3	81
Zamojskie			
Zamość	S-E	1	$> D_a$
	OB	1	30
Zwierzyniec	S-E	1	$> D_a$
	OB	1	24
Zielonogórskie			
Zielona Góra	S-E	2	56
Total		719	
of which:	S-E	386	
	OB	333	

Sources: Wyniki pomiarów imisji wykonanych w 1987 nadesłane przez ośrodki badań i kontroli środowiska; Wyniki pomiarów imisji wykonanych w 1987 przez stacje sanitarno-epimedmiologiczne.

Table 13.9. Average annual concentration of SO_2 in 1987. Allowable average concentration (D_a) in the protected regions equals 64 μg m^{-3}.

Province/ City	Measure- ments made by	No. of measuring stations	Average concentration (μg m^{-3})
Warszawskie			
Warszawa:			
Śródmieście	OB	8	72
Mokotów	OB	5	39
Praga Płn.	OB	24	55
Wola	OB	38	55
Żoliborz	OB	23	26
Grodzisk Mazowiecki	OB	26	66
Góra Kalwaria	OB	7	74
Kampinos	S-E	2	17
Konstancin	OB	6	39
Nowy Dwór Mazowiecki	OB	15	40
Otwock	S-E	1	26
Ożarów	OB	6	59
Piaseczno	S-E	1	28
Pruszków	S-E	1	37
	OB	18	70
Wołomin	OB	6	48
Białostockie			
Bialystock	S-E	2	31
Hajnówka	S-E	1	28
Bielskie			
Bielsko-Biała	S-E	2	47
Oświęcim	S-E	1	67
Szczyrk	S-E	1	$< 0.5D_a$
Bydgoskie			
Bydgoszcz	S-E	4	20
Chojnice	S-E	1	2
Inowrocław	S-E	1	30
Koronowo	S-E	1	3
Świecie	S-E	1	22
Chełmskie			
Chełm	S-E	2	29
Włodawa	S-E	1	22
Ciechanowskie			
Ciechanów	S-E	1	$< 0.5D_a$
Działdowo	S-E	1	$< 0.5D_a$
Mława	S-E	1	$> D_a$
Płońsk	S-E	1	$< 0.5D_a$
Częstochowskie			
Częstochowa	S-E	30	$< D_a$
	OB	2	56
Rejon Miasteczka Śląskiego	OB	1	67
Elbląskie			
Elbląg	S-E	3	29
Frombork	S-E	1	80
Kwidzyń	S-E	1	28

Table 13.9. Continued.

Province/ City	Measure- ments made by	No. of measuring stations	Average concentration (μg m^{-3})
Gdańskie			
Gdańsk:			
Śródmieście	S-E	1	69
	OB	2	8
Oliwa	S-E	1	23
	OB	1	19
Nowy Port	S-E	1	65
Gdynia	S-E	3	29
	OB	5	6
Kościerzyna	S-E	1	48
Puck	S-E	1	23
Rumia	OB	1	25
Sopot	S-E	1	53
Starogard Gdański	S-E	1	12
Wejherowo	S-E	1	25
Gorzowskie			
Gorzów Wielkopolski	S-E	4	$< D_a$
Jeleniogórskie			
Jelenia Góra	OB	1	59
Cieplice	OB	1	128
Rozdroże Izerskie	OB	1	23
Zgorzelec	OB	2	208
Działoszyn	OB	4	180
Bogatynia	OB	2	136
1ex] *Kaliskie*			
Kalisz	S-E	5	$< D_a$
Ostrów Wielkopolski	S-E	4	$< 0.5D_a$
	OB	22	28
Skalmierzyce	S-E	1	$< 0.5D_a$
Krotoszyn	OB	11	20
Katowickie			
Katowice	S-E	2	47
Będzin	S-E	1	42
Bytom	S-E	1	46
Chorzów	S-E	1	28
Chrzanów	S-E	1	122
Dąbrowa Górnicza	S-E	1	34
Jaworzno	S-E	1	53
Łaziska	S-E	1	56
Mysłowice	S-E	1	40
Olkusz	S-E	1	44
Pszczyna	S-E	1	37
Ruda Śląska	S-E	1	55
Tarnowskie Góry	S-E	2	93
Toszek	S-E	1	105
Tychy	S-E	1	54
Wodzisław	S-E	1	74
Zabrze	S-E	1	65
Zawiercie	S-E	1	50
Rudnik	S-E	1	104

Table 13.9. Continued.

Province/ City	Measure-ments made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Kieleckie			
Kielce	S-E	3	39
Busko Zdrój	S-E	1	68
Jędrzejów	S-E	1	21
Końskie	S-E	1	21
Ostrowiec	S-E	1	38
Skarżysko	S-E	1	41
Starachowice	S-E	1	30
Konińskie			
Konin	S-E	3	40
Kramsk	S-E	1	10
Turek	S-E	1	39
Krakowskie			
Kraków:			
Śródmieście	OB	1	41
	S-E	5	119
Krowodrza	S-E	4	98
Nowa Huta	S-E	3	107
Podgórze	S-E	3	92
Ojców	S-E	1	50
Myślenice	S-E	1	59
Swoszowice	S-E	1	71
Wieliczka	S-E	2	76
Zabierzów	S-E	1	82
Krośnieńskie			
Krosno	OB	5	20
Jasło	OB	6	42
Iwonicz Zdrój	S-E	1	28
Rymanów Zdrój	S-E	1	19
Komańcza	OB	1	57
Solina	OB	1	22
Ustrzyki Górne	OB	1	4
Koszalinskie			
Koszalin	S-E	3	42
Kołobrzeg	S-E	1	15
Legnickie			
Legnica	OB	4	41
	S-E	2	$> 0.5D_a$
Głogów	S-E	2	$> D_a$
	OB	3	44
Krzepów	OB	1	53
Jaczów	OB	1	51
Jawor	S-E	2	$> 0.5D_a$
Lubin	S-E	2	$> 0.5D_a$
Polkowice	S-E	1	$< 0.5D_a$
Moszowice	OB	1	62
Ścinawa	S-E	1	$< 0.5D_a$
Serby	OB	1	55

Table 13.9. Continued.

Province/ City	Measure-ments made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Szczyglice	OB	1	45
Żukowice	S-E	1	$> D_a$
Leszczyńskie			
Leszno	S-E	1	$> D_a$
	OB	2	34
Kościan	S-E	1	$> D_a$
Gostyń	S-E	1	$< D_a$
Lubelskie			
Lublin	S-E	3	26
Nałęczów	S-E	1	13
Bychowa	OB	3	67
Kraśnik	OB	4	64
Lubartów	OB	3	52
Łączna	OB	2	50
Opole Lubelskie	OB	4	38
Poniatowa	OB	3	56
Trawniki	OB	2	77
Łomżyńskie			
Łomża	S-E	1	2
Nowogród	S-E	1	1
Łódzkie			
Łódź:			
Śródmieście	S-E	4	56
Bałuty	S-E	5	37
Górna	S-E	4	47
Polesie	S-E	3	39
Widzew	S-E	4	35
Aleksandrów	S-E	1	40
Głowno	S-E	1	29
Pabianice	S-E	1	30
	OB	3	25
Zgierz	S-E	1	42
	OB	8	45
Nowosądeckie			
Nowy Sącz	S-E	2	96
Grybów	S-E	1	47
Krynica	S-E	2	60
Muszyna	S-E	1	83
Nowy Targ	OB	3	114
Piwniczna	S-E	1	53
Stary Sącz	S-E	1	63
Zakopane	OB	4	105
Żegiestów	S-E	1	68
Olsztyńskie			
Olsztyn	S-E	2	15
Biskupiec	S-E	1	15
Iława	S-E	1	23
Mrągowo	S-E	1	18

Table 13.9. Continued.

Province/ City	Measure- ments made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Opolskie			
Opole	S-E	1	21
	OB	8	25
Kędzierzyn–Koźle	OB	19	88
Ozimek	S-E	1	26
Strzelce Opolskie	OB	3	8
Zawadzkie	OB	2	15
Małapanew	OB	1	51
Ostrołęckie			
Ostrołęka	S-E	2	33
Brok	S-E	1	10
Maków Mazowiecki	S-E	1	35
Ostrów Mazowiecki	S-E	1	48
Przasnysz	S-E	1	35
Wyszków	S-E	1	40
Pilskie			
Piła	S-E	4	52
Czarnków	S-E	2	37
Chodzież	S-E	1	$< D_a$
Piotrkowskie			
Piotrków	S-E	3	30
	OB	9	54
Bełchatów	OB	9	37
Koluszki	OB	3	40
Niewiadów	OB	1	42
Opoczno	S-E	1	16
	OB	13	8
Radomsko	OB	19	159
Tomaszów Mazowiecki	S-E	1	121
	OB	13	93
Płockie			
Płock	S-E	7	11
	OB	3	22
Gostynin	S-E	1	13
Kutno	S-E	3	25
Sierpc	S-E	1	14
Poznańskie			
Poznań	S-E	3	82
Gniezno	S-E	1	95
Śrem	S-E	1	72
Przemyskie			
Przemyśl	S-E	2	15
Jarosław	S-E	1	14
Lubaczów	S-E	1	12
Przeworsk	S-E	1	13
Radomskie			
Radom	S-E	1	$< 0.5D_a$

Table 13.9. Continued.

Province/ City	Measure-ments made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Rzeszowskie			
Rzeszów	S-E	8	64
	OB	11	56
Łancut	OB	15	50
Mielec	OB	6	48
Ropczyce	S-E	1	88
	OB	4	52
Sędziszów	OB	6	45
Strzyżów	S-E	1	52
Szarzyna	OB	8	57
Siedleckie			
Siedlce	OB	5	162
Garwolin	OB	5	115
Kałuszyn.	OB	5	34
Łaskarzew	OB	5	62
Łochów	OB	5	39
Łuków	OB	5	23
Mińsk Mazowiecki	OB	5	61
Sokołów Podlaski	OB	5	22
Węgrów	OB	5	50
Żelechów	OB	5	52
Skierniewickie			
Skierniewice	S-E	2	3
Nieborów	S-E	2	21
Żyrardów	OB	3	41
Słupskie			
Słupsk	S-E	4	31
Miastko	S-E	1	17
Sławno	S-E	1	35
Człuchów	S-E	1	55
Lębork	S-E	1	212
Suwalskie			
Suwałki	S-E	1	19
	OB	3	14
Szczecińskie			
Szczecin	S-E	3	24
	OB	4	26
Gryfice	S-E	1	48
Tarnobrzeskie			
Tarnobrzeg	S-E	1	24
Baranów	S-E	1	22
Grębów	S-E	1	43
Janów Lubelski	S-E	1	42
Machów	OB	1	149
Stalowa Wola	S-E	1	28
	OB	1	10
Sandomierz	S-E	2	46
Staszów	S-E	1	19
Tarnowskie			
Tarnów	S-E	5	48

Table 13.9. Continued.

Province/ City	Measure-ments made by	No. of measuring stations	Average concentration (μg m^{-3})
Brzesko	S-E	1	34
Bochnia	S-E	1	46
Dębica	S-E	1	101
Dąbrowa Tarnowska	S-E	1	62
Niedomice	S-E	1	71
Żabno	S-E	1	68
Toruńskie			
Toruń	S-E	1	207
Grudziądz	S-E	1	123
Kowalewo	S-E	1	151
Wałbrzyskie			
Wałbrzych	S-E	4	125
	OB	1	50
Szczawno	OB	1	57
	S-E	1	250
Jedlina	S-E	1	106
Dzierżoniów	S-E	2	73
Świdnica	S-E	4	259
Włocławskie			
Włocławek	OB	3	90
Ciechocinek	OB	1	21
	S-E	3	40
Wieniec Zdrój	S-E	1	40
	OB	1	7
Aleksandrów	S-E	3	45
Lipno	S-E	1	45
Wrocławskie			
Wrocław:			
Stare Miasto	S-E	3	49
Śródmieście	S-E	3	74
Fabryczna	S-E	6	38
Krzyki	S-E	7	41
Psie Pole	S-E	4	36
Oleśnica	S-E	2	70
Oława	S-E	5	29
Strzelin	S-E	1	43
Środa Śląska	S-E	3	35
Wołów	S-E	2	28
Trzebnica	S-E	3	34
Zamojskie			
Zamość	S-E	1	$< 0.5D_a$
Zwierzyniec	S-E	1	$> D_a$
	OB	1	5
Zielonogórskie			
Zielona Góra	S-E	2	64
Total		894	
of which:	S-E	365	
	OB	529	

Sources: Wyniki pomiarów imisji wykonanych w 1987 nadesłane przez ośrodki badań i kontroli środowiska; Wyniki pomiarów imisji wykonanych w 1987 przez stacje sanitarno-epimedmiologiczne.

Table 13.10. Average annual concentration of NO_x in 1987. Allowable averge annual concentration (D_a) in the protected regions equals 22 μg m^{-3}.

Province/ City	Measure- ments made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Warszawskie			
Warszawa:			
Śródmieście	S-E	1	59
Wola	S-E	1	59
	OB	21	144
Mokotów	OB	13	90
Żoliborz	OB	23	72
Praga Płn.	OB	24	129
Ursus, Pruszków	OB	6	240
Otwock	S-E	1	24
Bielskie			
Bielsko-Biała	S-E	3	$> D_a$
Oświęcim	S-E	1	$> D_a$
Szczyrk	S-E	1	$> D_a$
Białskopodlaskie			
Biała Podlaska	S-E	1	$< 0.5D_a$
Bydgoskie			
Bydgoszcz	S-E	4	12
Inowrocław	S-E	1	23
Koronowo	S-E	1	8
Chojnice	S-E	1	8
Świecie	S-E	1	11
Chełmskie			
Chełm	S-E	1	41
Ciechanowskie			
Ciechanów	S-E	1	$> D_a$
Mława	S-E	1	$> D_a$
Częstochowskie			
Częstochowa	S-E	56	$D_a < 22$
	OB	2	29
Rejon Miasteczka Śląskiego	OB	1	151
Elbląskie			
Elbląg	S-E	1	21
Frombork	S-E	1	128
Kwidzyń	S-E	1	60
Gdańskie			
Gdańsk	S-E	4	32
	OB	2	70
Gdynia	S-E	3	30
	OB	5	67
Sopot	S-E	1	36
Kościerzyna	S-E	1	29
Puck	S-E	1	26
Rumia	OB	1	81
Starogard Gdański	S-E	1	26

Table 13.10. Continued.

Province/ City	Measurements made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Tczew	S-E	1	21
Wejherowo	S-E	1	42
	OB	5	80
Gorzowskie			
Gorzów Wielkopolski	S-E	4	53
Dębno Lubuskie	S-E	1	48
Jeleniogórskie			
Jelenia Góra	S-E	6	$> D_a$
Cieplice	S-E	2	$> D_a$
	OB	1	50
Bogatynia	S-E	4	$< D_a$
	OB	1	10
Bołesławiec	S-E	5	$> D_a$
Gryfów	S-E	2	$> D_a$
Karpacz	S-E	1	$> D_a$
Rozdroże Izerskie	OB	1	28
Kraśnik Dolny	S-E	1	$> D_a$
Łąka	S-E	1	$> D_a$
Pieńsk	S-E	2	$< D_a$
Rozdroże Izerskie	OB	1	28
Zgorzelec	S-E	2	$< D_a$
Kaliskie			
Kalisz	S-E	3	$> D_a$
Ostrów Wielkopolski	S-E	3	$> D_a$
	OB	16	114
Krotoszyn	OB	7	105
Katowickie			
Katowice	S-E	2	100
Będzin	S-E	1	112
Bytom	S-E	1	128
Chorzów	S-E	1	92
Chrzanów	S-E	1	109
Dąbrowa Górnicza	S-E	1	108
Jaworzno	S-E	1	113
Łaziska Górne	S-E	1	92
Mysłowicl	S-E	1	105
Olkusz	S-E	1	107
Pszczyna	S-E	1	–
Ruda Śląska	S-E	1	89
Miasteczko Śląskie	S-E	2	120
Toszek	S-E	1	87
Tychy	S-E	1	98
Wodzisław	S-E	1	174
Zabrze	S-E	1	84
Zawiercie	S-E	1	78
Rudnik	S-E	1	118
Kieleckie			
Kielce	S-E	1	48
Busko Zdrój	S-E	2	45

Table 13.10. Continued.

Province/ City	Measure- ments made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Krakowskie			
Kraków	S-E	1	44
	OB	1	27
Krośnieńskie			
Krosno	S-E	5	37
	OB	5	25
Iwonicz Zdrój	S-E	1	14
Jasło	S-E	3	60
Sanok	S-E	6	$< D_a$
Legnickie			
Legnica	OB	4	24
	S-E	1	$> D_a$
Chojnów	S-E	1	$> D_a$
Głogów	S-E	2	$> D_a$
	OB	3	26
Jaczów	OB	1	25
Krzepów	OB	1	33
Lubin	S-E	1	$> D_a$
Moszowice	OB	1	25
Polkowice	S-E	1	$> D_a$
Prochowice	S-E	1	$> D_a$
Serby	OB	1	23
Szczyglice	OB	1	24
Leszczyńskie			
Leszno	S-E	1	$> D_a$
Kościan	S-E	1	$> D_a$
Góra	S-E	1	$> D_a$
Lódzkie			
Łódź:			
Śródmieście	S-E	1	109
Bałuty	S-E	1	36
Górna	S-E	1	81
Widzew	S-E	1	530
Pabianice	S-E	1	56
Zgierz	S-E	1	340
	OB	6	31
Lubelskie			
Bychowa	OB	2	65
Kraśnik	OB	2	78
Lubartów	OB	2	58
Łączna	OB	2	55
Opole Lubelskie	OB	2	55
Poniatowa	OB	2	79
Trawniki	OB	2	65
Olsztyńskie			
Olsztyn	S-E	2	20
Biskupiec	S-E	1	27
Iława	S-E	1	25
Mrągowo	S-E	1	29
Szczytno	S-E	1	15

Table 13.10. Continued.

Province/ City	Measurements made by	No. of measuring stations	Average concentration (μg m^{-3})
Opolskie			
Opole	S-E	1	60
Kędzierzyn	OB	6	68
Korzonek	OB	5	15
Ostrołęckie			
Ostrołęka	S-E	1	17
Ostrów Mazowiecki	S-E	1	22
Brok	S-E	1	4
Pilskie			
Piła	S-E	3	$> D_a$
Chodzież	S-E	2	$> D_a$
Czarnków	S-E	1	$> D_a$
Piotrkowskie			
Piotrków Trybunalski	S-E	2	80
Płockie			
Płock	S-E	4	56
Kutno	S-E	1	87
Przemyskie			
Przemyśl	S-E	2	39
Radymno	S-E	1	38
Radomskie			
Radom	S-E	1	$< 0.5D_a$
Rzeszowskie			
Rzeszów	S-E	8	36
Glogów	S-E	1	$< D_a$
Siedleckie			
Siedlce	S-E	4	26
	OB	5	165
Garwolin	OB	5	89
Kałuszyn	OB	5	115
Łochów	OB	5	35
Łuków	OB	5	112
Mińsk Mazowiecki	OB	5	77
Sokołów Podlaski	OB	5	44
Węgrów	OB	5	102
Żelechów	OB	5	70
Skierniewickie			
Skierniewice	S-E	2	16
Brzeziny	S-E	1	153
Rawa Mazowiecka	S-E	1	145
Nieborów	S-E	1	43
Słupskie			
Słupsk	S-E	4	67
Szczecińskie			
Szczecin	S-E	3	45
	OB	4	24
Gryfice	S-E	1	27
Tarnobrzeskie			
Tarnobrzeg	S-E	1	42

Table 13.10. Continued.

Province/ City	Measure-ments made by	No. of measuring stations	Average concentration ($\mu g\ m^{-3}$)
Baranów	S-E	1	25
Janów Lubelski	S-E	1	36
Machów	OB	1	23
Sandomierz	S-E	2	26
Stalowa Wola	S-E	1	27
Tarnowskie			
Tarnów	S-E	5	39
Niedomice	S-E	1	22
Żabno	S-E	1	18
Toruńskie			
Toruń	S-E	1	78
Grudziądz	S-E	1	119
Kowalewo	S-E	1	55
Wałbrzyskie			
Wałbrzych	OB	1	37
Szczawno Zdrój	OB	1	32
Włocławskie			
Włocławek	S-E	4	60
	OB	3	64
Ciechocinek	S-E	1	15
	OB	1	76
Wieniec Zdrój	S-E	1	10
	OB	1	85
Aleksandrów	S-E	3	$< D_a$
Lipno	S-E	1	$< D_a$
Wrocławskie			
Wrocław:			
Stare Miasto	S-E	1	67
Śródmieście	S-E	2	70
Krzyki	S-E	1	52
Fabryczna	S-E	1	55
Psie Pole	S-E	1	36
Brzeg Dolny	S-E	1	$< D_a$
Oleśnica	S-E	2	29
Oława	S-E	1	40
Strzelin	S-E	1	$< D_a$
Środa Śląska	S-E	1	26
Wołów	S-E	1	44
Trzebnica	S-E	1	14
Zamojskie			
Zamość	S-E	1	$> D_a$
Zielonogórskie			
Zielona Góra	S-E	2	106
Total		500	
of which:	S-E	280	
	OB	220	

Sources: Wyniki pomiarów imisji wykonanych w 1987 nadesłane przez ośrodki badań i kontroli środowiska; Wyniki pomiarów imisji wykonanych w 1987 przez stacje sanitarno-epimedmiologiczne.

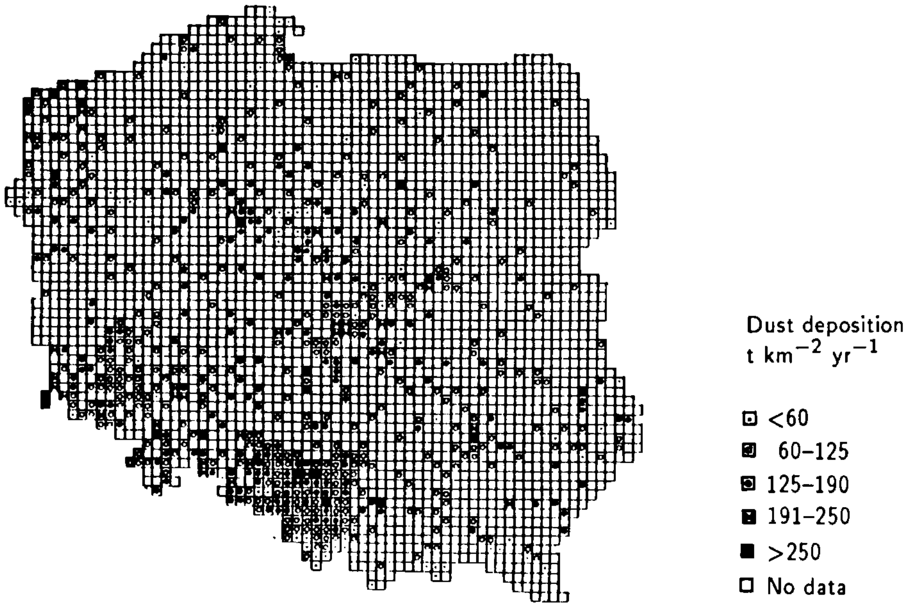

Figure 13.12. Distribution of dust deposition in Poland in 1987. Source: Nowicki, 1987.

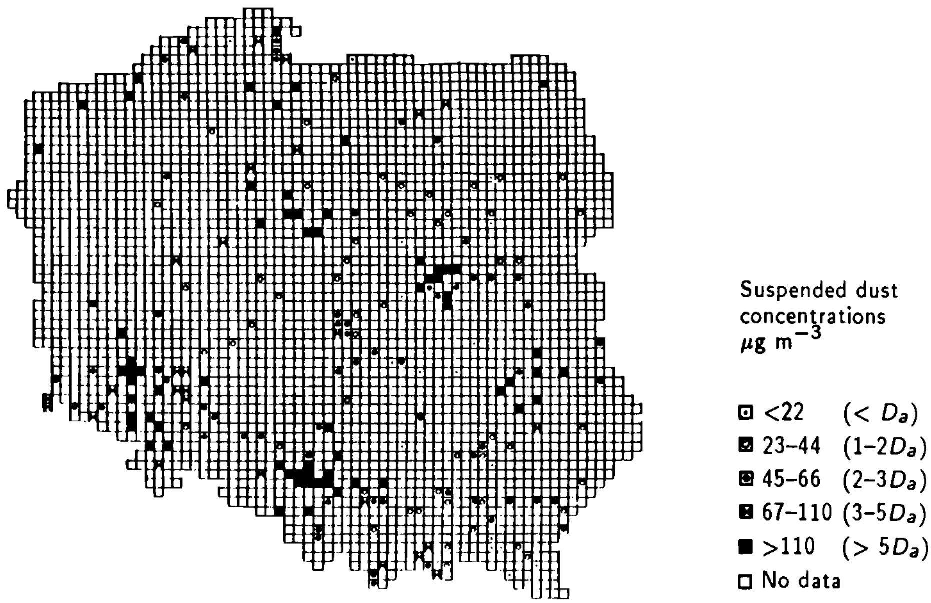

Figure 13.13. Distribution of average annual suspended dust concentration in Poland in 1987. Source: Nowicki, 1987.

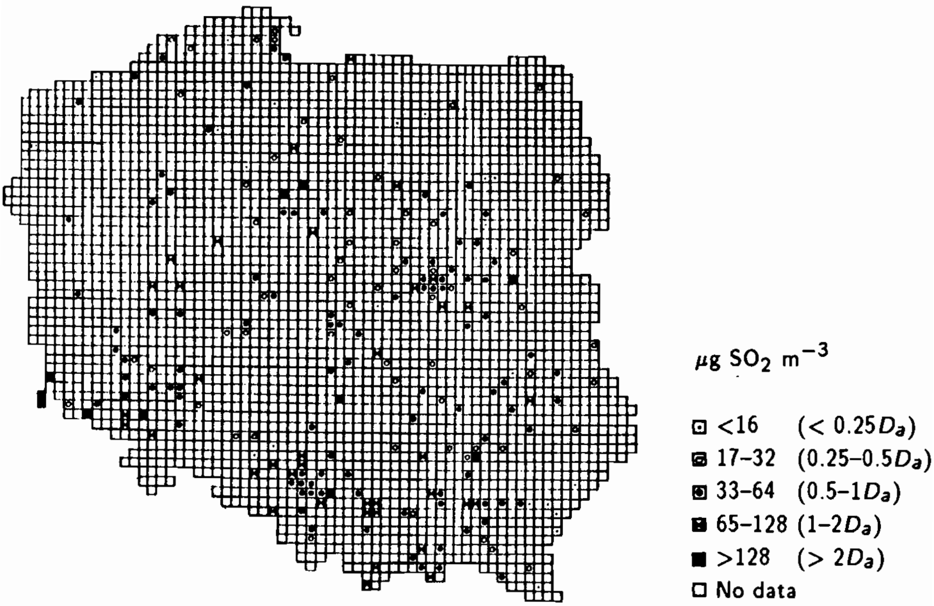

Figure 13.14. Distribution of average annual sulfur dioxide in Poland in 1987. Source: Nowicki, 1987.

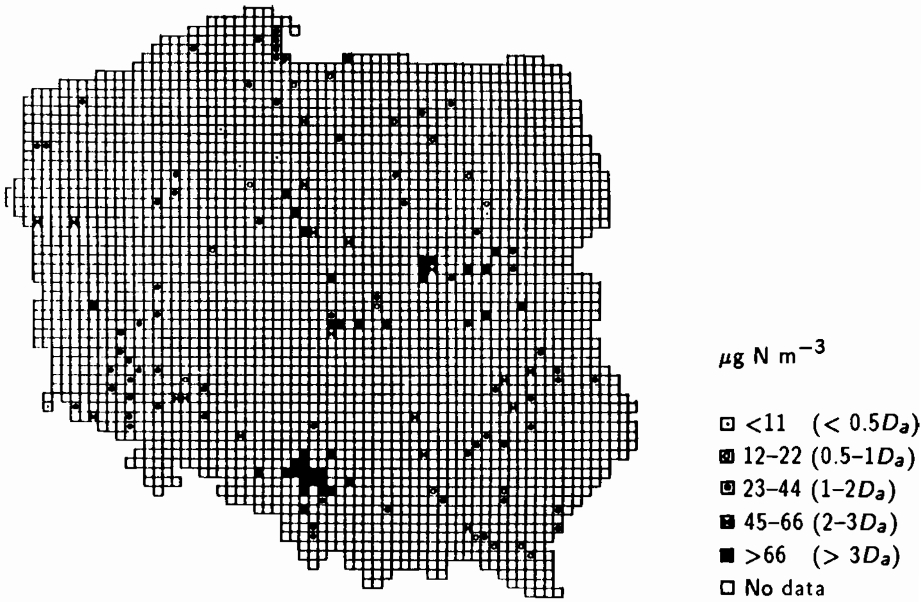

Figure 13.15. Distribution of average annual nitrogen concentration (N_2O_5) in Poland in 1987. Source: Nowicki, 1987.

13.2.3 Local monitoring

The measurements of air pollution at the most polluting industrial plants and in their protective zones are usually conducted by each plant's environmental protection service. These measurements supplement the urban monitoring system.

An attempt was made to compare the measurement programs carried out in 1987 at different industrial plants (*Table 13.11*). Although this list is incomplete because of collection problems (especially the absence of a national recording system), it shows that the local authorities have very different attitudes toward their responsibility for local pollution monitoring. It seems that soon local pollution monitoring should become an integral part of urban monitoring, and should be supervised directly by the relevant state inspectorates.

13.3 Comparing Air Pollution in Poland with Other European Countries

The most reliable source of information about the emissions of sulfur and nitrogen compounds in all European countries and about their transport across borders is EMEP, the program organized and supervised by the UN Economic Commission for Europe. Ever since the Convention on the Transboundary Transport of Air Pollutants in Europe was adopted in 1979, EMEP has been the main tool in determining the size of emissions in different countries, the ratio between SO_2 and NO_x imports and exports, and the effectiveness of steps taken to reduce these emissions.

Table 13.12 presents the size of SO_2 emissions in all European countries in 1987. These data illustrate that many countries reduced SO_2 emission by more than 30% relative to 1980 and that in Europe, overall, this emission dropped by 10%. Among the East European countries, the European USSR and Hungary were the most successful in reducing their SO_2 emissions by 20% and 13%, respectively. It is disturbing to see that SO_2 emission actually went up in Poland from 1980 to 1987, and that it remained at a very high stable level in East Germany during this period (5 million tons per annum). In 1987 the overall SO_2 emission recorded in the USSR, Poland, East Germany, and the CSFR amounted to as much as 53.4% of total SO_2 emissions in Europe. At present, Poland

Table 13.11. Survey of measuring programs undertaken in 1987 at industrial sites in different locations.

Province	No. of plants	No. of measuring stations: Dust particles	Concentration of suspended particles	Type of pollution at no. of points
Warszawskie	–	–	–	–
Bialskopodlaskie	–	–	–	–
Białostockie	–	–	–	–
Bielskie	–	–	–	–
Bydgoskie	25	–	–	20 substances
Chełmskie	2	–	12	–
Ciechanowskie	–	–	–	–
Częstochowskie	–	–	–	–
Elbląskie	1	–	12	30-min. measurement
Gdańskie	18	–	–	–
Gorzowskie	2	–	16	SO_2/16, H_2S/16
Jeleniogórskie	3	32	2	SO_2/14, NO_x/H_2S/CS_2
Kaliskie	–	–	–	–
Katowickie	14	62	1	SO_2/42, NO_x/3
Kieleckie	18	–	–	–
Konińskie	–	–	–	–
Koszalinskie	–	–	–	–
Krakowskie	9	–	19	SO_2/14, F_2/16
Krośnieńskie	1	21	21	SO_2/21, NO_x/21, F_2/21
Legnickie	1	–	9	SO_2/9, H_2SO/9, F_2/9
Leszczyńskie	–	–	–	–
Lubelskie	10	–	–	–
Łomżyńskie	–	–	–	–
Łódzkie	–	–	–	–
Nowosądeckie	1	4	4	SO_2/4, NO_x/4
Olsztyńskie	–	–	–	–
Opolskie	11	99	29	SO_2/29, NO_x/11
Ostrołęckie	3	–	–	6 substances
Pilskie	1	7	–	–
Piotrkowskie	2	–	–	3 substances
Płockie	–	–	–	–
Poznańskie	–	–	–	–
Przemyskie	–	–	–	–
Radomskie	–	–	–	–
Rzeszowskie	1	–	–	SO_2/6
Siedleckie	–	–	–	–
Sieradzkie	2	–	9	SO_2/4
Skierniewickie	3	27	14	SO_2/14, H_2S/6, CS_2/6
Slupskie	–	–	–	–
Suwalskie	–	–	–	–
Szczecińskie	2	–	–	SO_2/14, F_2/6, NH_3/6
Tarnobrzeskie	8	–	8	SO_2/10, NO_x/7
Tarnowskie	3	–	7	SO_2/8, NO_x/7
Toruńskie	3	–	–	–
Wałbrzyskie	–	–	–	–
Włocławskie	1	–	9	SO_2/9, NO_x/9, C_nH_m/9
Wrocławskie	25	–	–	–
Zamojskie	–	–	–	–
Zielonogórskie	2	10	–	SO_2/10, phenol/5,
Total	172	262	172	SO_2/224, NO_x/62

Source: Nowicki, 1987.

Table 13.12. Emissions of SO_2, in 1,000 tons per year.

Country	Code	1980	1987[a]	%[b]
Albania	AL	50	50	100
Austria	AT	354	150	42
Belgium	BE	800	488	61
Bulgaria	BG	1,034	1,070	103
CSFR	CS	3,100	2,900	94
Denmark	DK	438	310	71
East Germany	DD	5,000	5,000	100
Finland	FI	584	324	55
France	FR	3,512	1,518	43
Greece	GR	400	360	90
Hungary	HU	1,634	1,420	87
Ireland	IE	220	168	76
Italy	IT	3,800	2,504	66
Netherlands	NL	488	282	58
Norway	NO	140	100	71
Poland	PL	4,100	4,300	105
Portugal	PT	266	232	87
Romania	RO	200	200	100
Spain	ES	3,250	3,162	97
Sweden	SE	464	232	50
Switzerland	CH	126	62	49
UK	GB	4,670	3,680	79
West Germany	DE	3,200	2,044	64
Yugoslavia	YU	1,176	1,176	100
European USSR	SU	12,800	10,200	80
Total		51,806	41,932	81

[a]Figures for 1987 for Poland do not agree with figures in this chapter.
[b]Value of emission in 1987 in relation to 1980, in percent.
Source: EMEP, 1988b.

and its closest neighbors pose a big threat to air purity in Europe due to their SO_2 emissions.

Table 13.13 contains a balance sheet of sulfur compounds' exports and imports in Poland in 1987 compiled at the EMEP Synthesizing Center in Oslo. On the one hand, it shows that only 35% of the SO_2 emitted in Poland remains in this country. The rest is transported out of Poland in the form of gas (SO_2) or aerosol (sulfates) and is deposited in other European and non-European countries. On the other hand,

Table 13.13. Balance of transboundary transport of sulfur to and from Poland, in 1,000 tons per year of SO_2 in 1987.

Country	From Poland	To Poland
Austria	30	6
Bulgaria	10	2
CSFR	184	290
East Germany	62	620
Finland	24	0
France	30	24
Hungary	48	80
Italy	28	20
Norway	22	0
Romania	64	2
Switzerland	64	2
UK	6	30
West Germany	44	94
Yugoslavia	46	22
European USSR	654	36
Rest of Europe	32	32
Total, balance of Europe	1,348	1,260
Internal deposition of sulfur		1,532
Export to outside Europe	1,420	

Source: EMEP, 1988b.

as much as 1 million tons of sulfur compounds reach Poland and its southwestern parts (particularly from Germany and the CSFR). Southwestern Poland, southeastern Germany, and northern Bohemia are the most seriously SO_2 polluted areas of Europe. This fact was confirmed by measurements taken within the framework of the EMEP program in 1985. *Figure 13.16* presents the distribution of average annual SO_2 concentration in Europe, and *Figure 13.17* displays the distribution of annual sulfur deposition. These maps show that the annual SO_2 concentration in 1985 in the Sudety exceeded 50 micrograms per cubic meter, which is characteristic of coniferous regions with the highest degree of damage. At the same time, three-fourths of Poland's territory is inside the isoline of 20 micrograms per cubic meter, which causes the first degree of damage to forests.

The data collected by the EMEP Synthesizing Center in Oslo on the emissions of nitrogen compounds [oxides (NO and NO_2) and ammonia

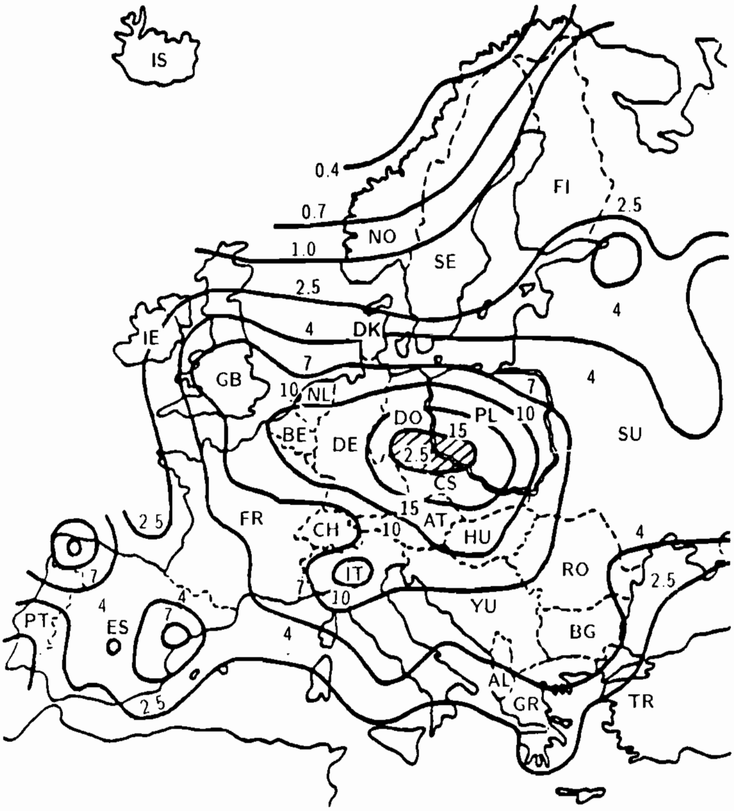

Figure 13.16. Distribution of average annual SO_2 concentration in Europe in 1985.

(NH_3)] in all European countries were included in *Table 13.14*. These data indicate that the largest amount of nitrogen oxides was emitted in West Germany, the UK, France, and Italy (where the emission was mostly caused by vehicles) and in the USSR and Poland (mainly by stationary sources). Emissions of NO_x in Poland, the USSR, East Germany, and the CSFR amounted to approximately 33% of the European NO_x emissions in 1985.

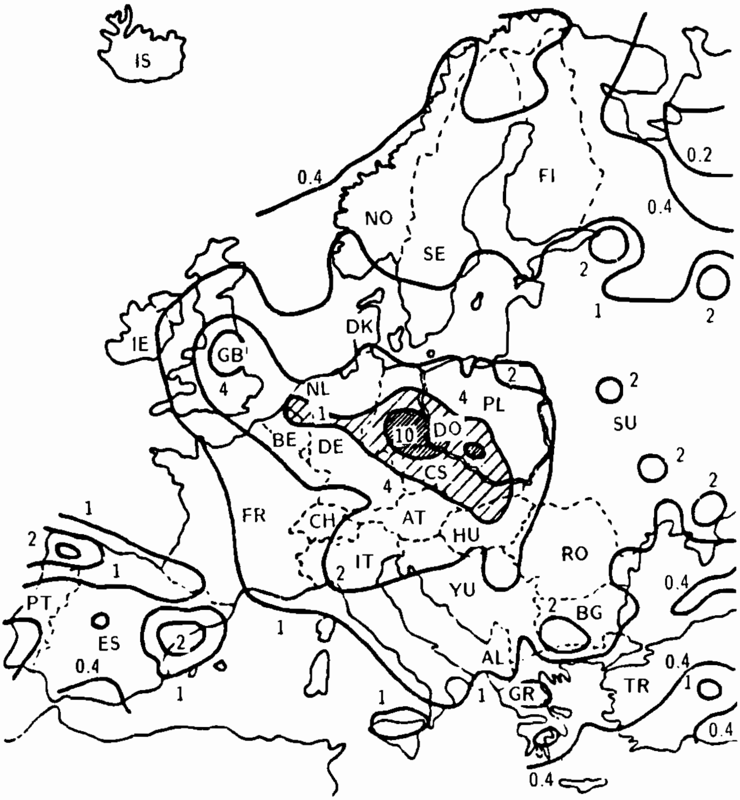

Figure 13.17. Distribution of total deposition of sulfur compounds in Europe in 1985.

Figures 13.18 and *13.19* illustrate the distribution of average annual NO_x concentration and nitrogen compounds deposited throughout Europe in 1985; these figures were calculated at the Synthesizing Center–West with the help of a long-range transport model. In this case too, the maximum concentration was recorded in southwestern Poland. Poland's largest industrial centers (from Turow to Cracow) receive the highest amount of acid deposition in all Europe, which results in ecological

Table 13.14. Emissions of nitrogen from European countries, in 1,000 tons per year, in 1985.

Country	NO_x (as NO_2)	NH_3	$NO_x + NH_3$ (as nitrogen)
Albania	9	24	23
Austria	216	85	136
Belgium	385	95	195
Bulgaria	150	148	167
CSFR	1,127	200	508
Denmark	238	132	181
East Germany	995	242	491
Finland	240	52	115
France	1,693	841	1,208
Greece	150	113	139
Hungary	300	151	216
Ireland	68	140	135
Italy	1,595	426	836
Netherlands	537	170	303
Norway	223	41	102
Poland	1,500	479	851
Portugal	192	55	103
Romania	390	350	407
Spain	950	272	513
Sweden	301	61	143
UK	1,840	478	954
West Germany	2,900	438	1,243
Yugoslavia	190	235	252
European USSR	2,930	3,180	3,511
Total	19,468	8,470	13,478

Source: EMEP, 1988a.

catastrophes in forests, acidification of soil, decreased farm production, greater susceptibility of residents to diseases, and serious material losses (corrosion of metals and stone used in construction). These areas should therefore be granted priority in the national program for air protection.

Table 13.15 lists heavy metals' emission figures in the European countries (Pacyna, 1986). Poland ranks particularly high on this list in emissions of arsenic and cadmium (15% of the total European emissions) and of chromium, copper, mercury, and zinc (6% to 9% of the European emissions). The USSR, West Germany, and Poland are the greatest

Table 13.15. Emissions of heavy metals from European countries, in tons per year, in 1982.

Country	Arsenic	Cadmium	Chromium	Copper	Mercury[a]	Lead	Vanadium	Zinc
Albania	31	1	5	71	31	134	43	72
Austria	43	6	200	134	1,145	1,933	552	4,370
Belgium	360	51	642	613	1,874	3,986	908	4,736
Bulgaria	152	67	181	288	988	2,234	701	1,722
CSFR	86	23	791	323	793	1,726	943	635
Denmark	7	9	50	38	1,118	753	596	706
East Germany	133	36	528	376	1,244	2,084	965	746
Finland	127	23	115	246	641	1,621	565	2,460
France	228	85	1,095	450	3,492	10,545	2,338	6,127
Greece	10	3	77	55	125	1,303	372	121
Hungary	34	8	198	509	160	888	389	280
Ireland	2	1	11	13	0	456	199	33
Italy	93	54	1,055	385	2,025	9,365	3,952	4,420
Netherlands	38	11	255	105	1,405	2,427	979	3,067
Norway	17	4	40	56	312	803	160	1,188
Poland	656	207	1,161	1,313	3,036	4,568	672	4,725
Portugal	7	2	27	29	16	525	268	39
Romania	35	13	619	228	737	1,827	660	614
Spain	302	124	571	565	1,069	5,534	1,373	3,255
Sweden	147	19	195	237	138	2,270	1,003	346
Switzerland	1	11	40	18	4	1,083	130	50
UK	164	51	1,134	580	2,489	10,098	2,074	3,488
West Germany	354	148	2,153	1,552	4,676	9,308	2,222	11,689
Yugoslavia	134	65	205	287	851	2,423	718	2,013
European USSR	1,064	280	7,147	6,535	8,111	43,842	11,262	21,282
Total	4,225	1,302	18,495	15,006	36,480	121,736	34,044	78,183

[a]Emissions in kilograms per year.

Source: Pacyna, 1986.

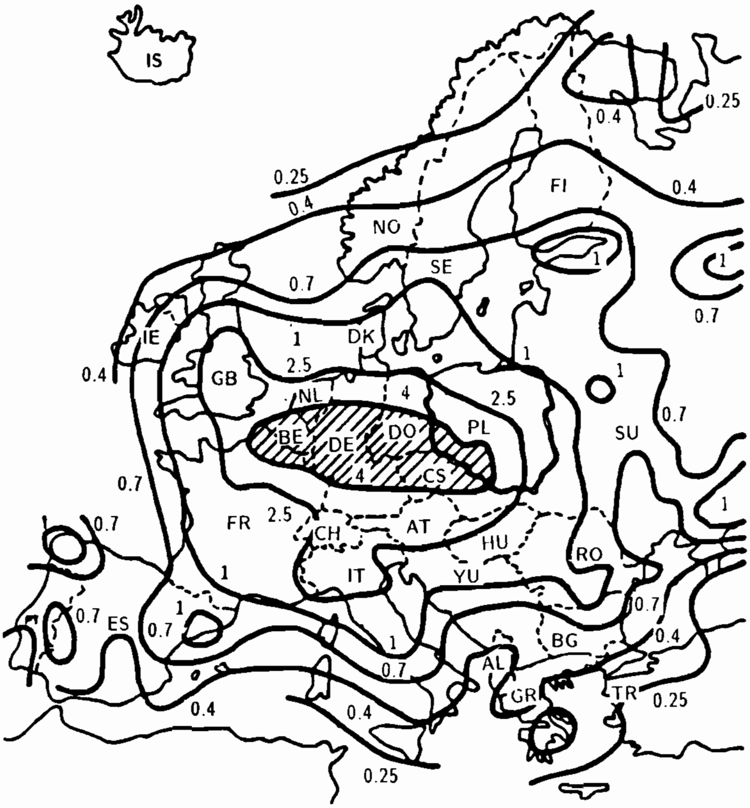

Figure 13.18. Distribution of average annual nitric oxides concentration in Europe in 1985.

sources of these highly toxic pollutants. These emissions are strongly connected with nonferrous metallurgy and coal burning at power stations. Vehicles are another important source of these pollutants. Therefore it is clear that the national air-protection program should pay much more attention to reducing heavy metals' emissions.

Although it is still far from perfect, the emission and ambient data estimated in recent years within the framework of the EMEP have made

Figure 13.19. Distribution of total deposition of oxidized nitrogen compounds in Europe, in 1985.

it possible to compare air pollution in Poland with that in other European countries. These data leave no doubt that Poland belongs to the group of countries with the highest emissions of many toxic substances and that it receives large quantities of these substances from its neighbors. It is therefore necessary to take decisive steps to reduce the emissions of these pollutants in Poland, and at the same time participate in international actions designed to control air pollution in neighboring countries.

13.4 Conclusion

The data included in this chapter indicate the following:

- The major air pollutants in Poland are sulfur dioxide, nitric oxides, and industrial dust in general, and heavy metals' dust in particular.
- The emissions of these pollutants are concentrated in a few provinces; emissions in the Katowice province amounts to 20% of the national emissions.
- Poland places among the countries with the highest SO_2, NO_2, and heavy metals' emissions in Europe; in recent years, contrary to the downward trend recorded in other parts of Europe, these emissions have increased in Poland.
- The transboundary transport of sulfur and nitrogen compounds from the west and south, accompanied by Poland's own emissions, has produced the situation in which southwestern Poland is exposed to the biggest threat from air pollution in Europe.
- Ambient measurements taken by environmental protection stations and the OB stations indicate that in 1987 the allowable limits for suspended dust, nitric oxides, and, to a lesser degree, sulfur dioxide were surpassed – in many cases by more than a factor of five. This result is alarming and merits urgent and effective measures to reduce pollutant emissions.

An additional purpose of this chapter was to present a comprehensive evaluation of air-pollution monitoring in Poland to date. The monitoring system is highly unsatisfactory and requires an immediate and substantial reform. The most serious shortcomings of air-pollutants' ambient measurements are absence of uniform instructions concerning the method of manual measurements; absence of uniform measurement methods to determine a pollutant's concentration; the disastrous state of background monitoring; lack of automatic monitoring networks in the most polluted parts of the country; lack of locally produced high-quality automatic control and measurement equipment; absence of a national system of measurements, quality control, equipment calibration, and laboratory intercalibration; and problems with recording measurements caused by the lack of an adequate computer data bank.

These problems are being studied at the Environmental Protection Institute, within the framework of the Ministry of Environmental Protection and Natural Resources' "R-3 Program" and the State Environment Monitoring Project sponsored by this ministry. These efforts should contribute to creating a national, uniform air-pollution monitoring system in the 1990s, which should provide a reliable measurement basis for developing an optimum strategy for Poland's economic and urban development, and for taking efficient measures for air protection.

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Chapter 14

Quality of the Environment in Romania

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In recent decades the environment in Romania has suffered major damage from industrialization, agricultural chemicals, and forced urbanization. Another factor contributing to this damage was the intensive and irrational exploitation of natural resources with total disregard for ecological consequences. Environmental quality in Romania was thus seriously affected. In this chapter we briefly describe the current state of the environment.

14.1 Water Quality

Water quality in Romania is evaluated using standardized water-quality parameters designated in the document STAS 4706-88. On the basis of these parameters water is classified into three categories with quality progressively decreasing from category I to category III. Water is considered "degraded" when its quality falls below the parameters of category

III. In this chapter we describe water problems in Romania using these categories as a reference point.

14.1.1 River water

The total hydrographic network of Romania stretches approximately 70,000 kilometers of which about 20,000 kilometers have been investigated. The values of the water-quality parameters obtained during 1989 indicate that about 7,800 kilometers (39% of the length investigated) fall within category I, about 6,100 kilometers (30.5%) within category II, 2,400 kilometers (12%) in category III, and the remainder, about 3,700 kilometers, can be classified as degraded water (*Figure 14.1*; Cuşa, 1990).

A critical situation was identified in the following hydrographic basins: Ialomiţa, where about 51% of the hydrographic network investigated is degraded; Olt, about 38%; Siret, about 29%; Vedea, about 23%; and Argeş, about 22%. *Table 14.1* presents the main rivers affected by pollution as well as the reasons for this phenomenon.

If the values of the water-quality parameters obtained in 1989 are compared with those obtained between 1986 and 1988, a decrease in water quality is noticeable. In this period the total length of the rivers with category I water quality decreased from 45% to 39% and the total length of the rivers with degraded water increased from 15% to 18%.

14.1.2 Lake water

Lakes in Romania have good water quality, generally category I, but there are some lakes with water quality in category II and category III. There also are some lakes with degraded water quality. For example, Călineşti Oaş in the hydrographic basin (HB) of Someş; Băbeni, Govora, and Vîlcea in the Olt basin; Snagov in the Lalomiţa basin; Balta Albă in the Siret basin; Negreni in the Prut basin; Nuntaşi, Istria, Siutghiol, and Tăbăcăriei in the coastal basin of the Black Sea.

14.1.3 Coastal water (Black Sea)

Water quality in the Black Sea area of the Romanian resorts is sufficient for its main purposes – bathing and tourism. Exceptions are the vicinity

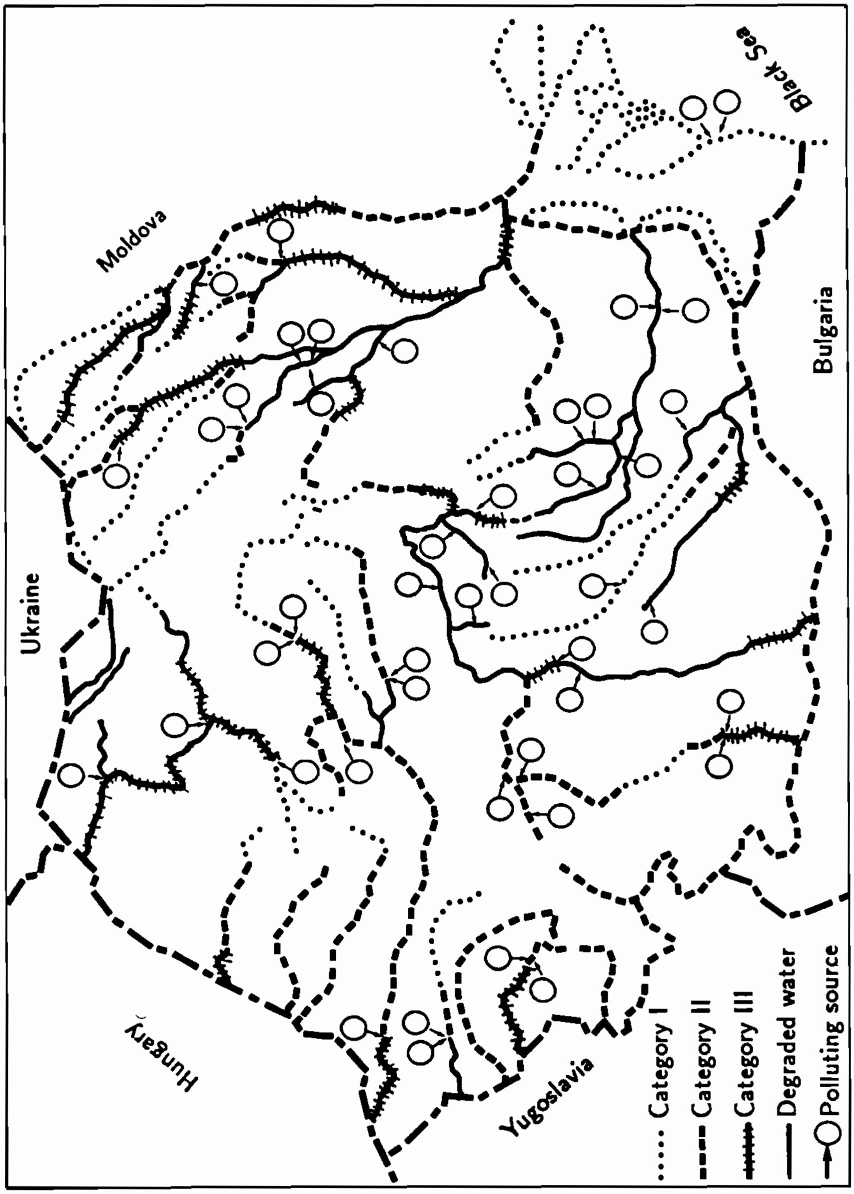

Figure 14.1. Water-quality problems in Romania.

Table 14.1. Polluted rivers in Romania and their causes.

River	Sections with "degraded" water From	To	Approx. distance km	Causes of degradation
Ialomiţa	Confluence with Prahova	Flows into Danube	200	Oil industry, chemical industry, petrochemistry
Prahova	Cimpina area	Flows into Ialomiţa	120	Oil industry, petroleum-refining industry
Olt	Confluence with Birsa	Confluence with Lotry	280	Pulp and paper industry, dye industry, chemical industry, livestock
	Vîlcea area	Confluence with Olteţ	130	Chemical industry, sodium chloride electrolysis, Solvay process nonferrous metallurgy, livestock
Siret	Confluence with Suceava	Confluence with Bistriţa	135	Chemical industry, pulp and paper industry, ore mining
	Confluence with Bistriţa	Confluence with Buzau	205	Chemical industry, rubber industry, petroleum-refining industry, fertilizer industry, livestock
Vedea	Confluence with Cotmeana	Confluence with Teleorman	100	Oil industry
Argeş	Confluence with Dimbovita	Flows into Danube	30	Wastewaters from Bucharest
Dimbovita	Bucharest area	Confluence with Argeş	40	Wastewaters from Bucharest
Neajlov	Găieştic area	Flows into Argeş	100	Petroleum-refining industry, chemical industry (pesticides), petrochemicals
Someş	Dej area	Confluence with Almas	85	Pulp and paper industry
Tirnava Mare	Copşa Mică area	Confluence with Mureş	60	Chemical industry, nonferrous metallurgy
Cerna	Hunedoara area	Flows into Mureş	20	Ferrous metallurgy
Bahlui	Podul Ilioaiei area	Flows into Prut	40	Wastewaters from Iasi, livestock

of the big towns of Constanţsa and Mangalia where large bacterial concentrations have been observed, sometimes with excessively high counts. This is due to improperly operated wastewater-treatment plants. Water samples obtained from Constanţsa and Mangalia harbors also contain high concentrations of oil.

In the summer, excessive phytoplankton growth in the Danube delta and coastal waters is due not only to climatic conditions favorable to plankton growth but also to high concentrations of nitrogen and phosphorus compounds. However, this phytoplankton proliferation has not hindered bathing.

14.1.4 Groundwater

Investigations made in 1989 show that there are signs of deteriorating groundwater quality. This was indicated by high concentrations of ammonia, nitrate, and organic compounds, as well as high bacterial counts. Data obtained by the health ministry show that bacterial counts in groundwater have increased in rural well-water supply. Based on these data, it seems that some sources of drinking water need to be treated. *Table 14.2* presents the areas where groundwater is most affected by chemical and bacterial pollution.

14.1.5 Causes of quality deterioration in natural waters

The direct discharge of wastes into natural waters is the main cause of their deterioration. Using data from our investigations, it was estimated that streams in Romania receive nearly 6.875 million tons of pollutants per year – chiefly chloride, suspended solids, organic matter, ammonium, ammonia, nitrates, nitrites, detergents, phenols, sulfides, sulfites, sulfates, hydrogen sulfide, phosphorus compounds, cyanides, and pesticides.

Most of these chemicals, which generally appear in high concentrations in effluents, are very useful substances, and restrictive use of them is an increasing financial burden to industrial plants. The deterioration of natural water quality has also caused great difficulties in water supply, and increasing costs of water to industry by more than fivefold. In some instances water supplies have had to be changed to obtain drinking

Table 14.2. Areas in Romania with polluted groundwater.

Hydrographic basin	Affected area
Someş	Around Gherla and Dej and the passage of the Someş
Crisuri	Passage of Bareău and Crişuri, the lower Crişuri valley
Mureş	Reghin–Tirgu Mureş area, downstream of Tirgu Mureş areas, Ocna Mureş, passage of Tirnave, downstream of Arad
Timiş	Passage of Timiş, downstream of Timişoara area, passage of Birzava
Jiu	Passage of Jiu
Olt	Downstream of Miorcurea Ciuc to Turnu Rosu area, depression of Sibiu, downstream of Rimnicu Vîlcea to confluence with Danube
Argeş	Valleys of Dimbovnic and Neajlov and downstream at Bucharest area
Ialomiţa	Prahova–Teleajen area, passage of Ialomiţa
Siret	Passages of Bistriţa (downstream of Piatra Neamt) of Suceava, of Trotuş (depression of Comănesti), of Siret (downstream of Roman), of Buzău (downstream of Buzău)
Prut	Lower Jijia valley
Danube	Downstream of Turnu Severin and Turnu Măgurele areas, valley of Danube from Giurgiu to downstream of Galaţi
Black Sea coastline	Irrigated fields

water. *Figure 14.1* and *Table 14.2* present the main wastewater sources of pollution, as well as the principal industries that cause the pollution.

The chemical and petrochemical industry, the dye industry, the pulp and paper industry, and coke-burning plants are among the significant polluters. The best-known examples are pulp and paper combines (Dej, Zărneşti, Bacău, Piatra Neamţ, Suceava), chemical fertilizer plants (Tg. Mureş, Arad, Bacău, Victoria, Făgăraş, Rosnov, Slobozia, Craiova, Valea Călugărească), synthetic dye plants (Codlea, Giurgiu), and other chemical plants (Govora, Săvineşti, Copşa Mică, Suceava, Midia-Năvodari). Other large sources of pollution are metallurgical plants: both iron and steel metallurgy (Reşiţa, Hunedoara, Galaţi, Călăraşi) and nonferrous metallurgy (Copşa Mică, Zlatna, Baia Mare).

Large towns like Iaşi, Timişoara, Cluj, and Braşov are heavy polluters because their wastewater-treatment plants are improperly operated. Bucharest has no wastewater-treatment plant.

To these polluting sources must be added wastes from the food industry and livestock. In addition, the wastewater-treatment plants using Romanian technology and equipment are inefficient because of unreliable power supplies and equipment and faulty operation by inadequately trained staff.

14.2 Air Quality

Air quality is evaluated in Romania using guidelines called "STAS 12574-87." The following compounds are usually investigated to test air quality: sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ammonia (NH_3), hydrogen sulfide (H_2S), chlorine (CL_2), fluorine (F_2), and suspended particles. It is estimated that about 1.8 million tons of pollutants are spewed into the atmosphere each year (Hâncu, 1990). Among these are: about 1.76 million tons of sulfur dioxide, 8,500 tons of ammonia, 5,500 tons of carbon sulfide, and 2,300 tons of phenols. Nonferrous metal compounds, such as chlorine, fluorine, and suspended and sedimentary particles, also are discharged into the air (*Figure 14.2*).

The air-pollution sources that cause the most damage are:

- Nonferrous metallurgy in Copşa Mică, Baia Mare, Zlatna, Slatina, and Moldova Nouă. Sulfur dioxide concentrations frequently exceed permitted limits in Copşa Mică, Baia Mare, and Zlatna – concentrations more than tenfold above permissible health limits have been recorded. Other pollutants encountered in these areas are particles containing lead and cadmium – concentrations frequently exceeding health limits by over 80%, with maximum concentrations 100 times above permitted limits (Mărcuţă and Serban, 1990). In the Slatina area, which has an aluminum-processing industry, the main pollutants are suspended particles and fluorine – concentrations exceeding health limits by a factor of ten.

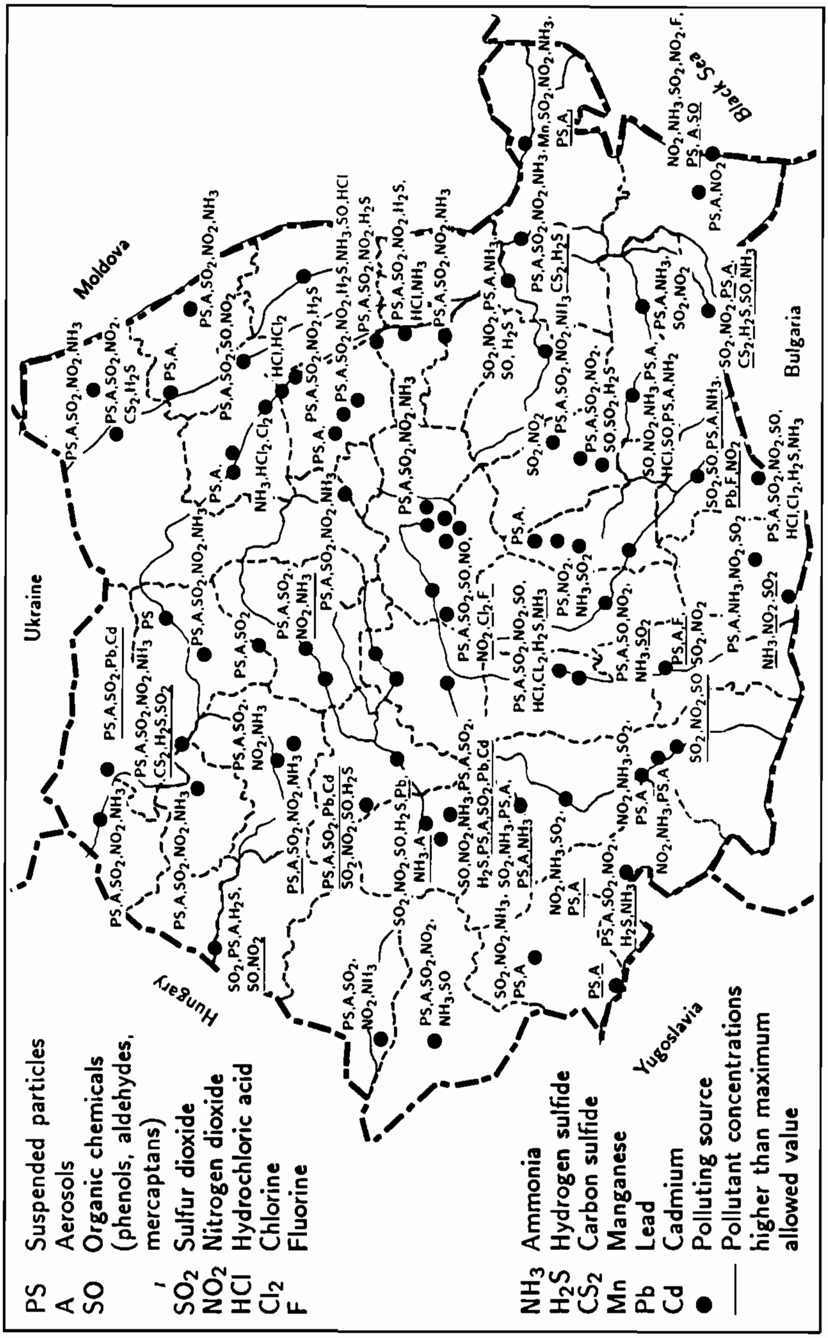

Figure 14.2. Air-pollution sources in Romania.

- The metallurgy of iron, steel, and coke in Reşiţa, Hunedoara, Călan, Galaţi, and Călăraşi areas. In these areas concentrations of suspended particles frequently exceed health standards.
- The pulp and paper industry and artificial fibers industry in the Dej, Brăila, Suceava, and Lupeni areas. Pollution in these areas comprises carbon sulfide, hydrogen sulfide, chlorine, hydrochloric acid, and other compounds.
- The chemical industry in the Borzeşti, Dej, Turnu, Severin, Făgăraş, Arad, Tg. Mureş, Işalniţa, and Turnu Măgurele areas. These areas are chiefly polluted by chloride, hydrogen sulfide, sulfuric acid, ammonia, and hydrochloric acid.
- The petrochemical industry of the Midia-Năvodari, Borzeşti, Piteşti, and Ploeşti Brazi areas where hydrocarbons, phenols, nitric oxides, sulfur dioxide, aldehydes, mercaptans, and fluorine are emitted into the atmosphere.
- The cement and construction materials industry in the Turda, Fieni, Tg. Jiu, Medgidia, Tulcea, Comarnic, and Bicaz areas where concentrations of suspended particles in the air are clearly above standards.
- Power stations in Rovinari, Turceni, Mintia-Deva, Paroşeni, Oradea, and Iaşi emit large amounts of sulfur dioxide, nitric oxides, and suspended particles.

These areas house industries that emit very concentrated amounts of pollution. The gas purification installations in these areas are inefficient and improperly operated. Many plants have no pollution-reduction equipment, allowing large amounts of pollutants to be discharged into the atmosphere.

One of the worst effects of atmospheric pollution is acid rain. It is presumed that in Romania acid rain is mainly caused by sulfur dioxide from various sources: power stations, industries, and domestic heating (Negulescu, 1990). At present sulfur dioxide is simply dispersed in the atmosphere by means of chimneys, but these smokestacks only serve to dilute local pollution and do not remove it. Romania lacks special installations to convert the sulfur dioxide present in burned gases into sulfur trioxide and subsequently into sulfuric acid. This applies also to power stations currently in the planning stage.

Acid rain can also be caused by nitric oxides from both large chemical fertilizer plants and power stations. Although large amounts of nitric oxides are produced by cars, they are not a problem in Romania where cars are few.

Figure 14.3 presents areas where acid rain was detected in 1989. As a general rule these areas also coincide with the location of large air-pollution sources. Alkaline rains were also recorded in 1989 in the Bihor, Neamţ, Hunedoara, and Bistriţa districts.

14.3 Soil Quality

The most important soil problem in Romania is erosion which affects about 5 million hectares of agricultural land. Additionally, about 0.7 million hectares are affected by landslides (Răuţă and Cârstea, 1990).

Investigations show that about 150 million tons of topsoil, which includes 1.5 million tons of humus, 0.4 to 0.5 million tons of nitrogen, phosphorus, and potassium, and large amounts of nutrient elements (calcium, manganese, zinc, molybdenum), are lost through erosion. Total erosion of agricultural land in Romania varies from 32 to 41 tons per hectare per year. The weighted average value is approximately 16.3 tons per hectare per year; this is very high in comparison to the 3 to 6 tons per hectare per year replaceable by natural soil regeneration. Investigations show that this very dangerous erosion process is increasing.

Another problem is chemical pollution in soils caused by industry; this includes chemical, ferrous and nonferrous metallurgy, oil extraction, cement and cementing materials, and mining. Livestock and power station emissions add to this pollution. Large amounts of dangerous chemicals are spread on agricultural land through irrigation. Pesticides are significant sources of chemical pollution in soils. In sum, it is estimated that about 0.9 million hectares of land are contaminated, 0.2 million hectares so badly as to be totally unproductive (*Figure 14.4*).

High concentrations of heavy metals were found in soils in Copşa Mică, Slatina, and Baia Mare, where there are large plants for nonferrous metallurgy and heavy metals concentrations are much higher than maximum permissible values (Pb-100 ppm; Cd-3 ppm; Zn-300 ppm; Cu-100 ppm). In some areas, concentrations of these metals reached very high values (Pb-3,000 ppm; Cd-100 ppm; Cu-1,300 ppm; Răuţă and Cârstea, 1990). Soil pollution by fluorine from chemical plants also was noted (Năvodari, Valea Călugărească, Tg. Mureş, Turnu Măgurele,

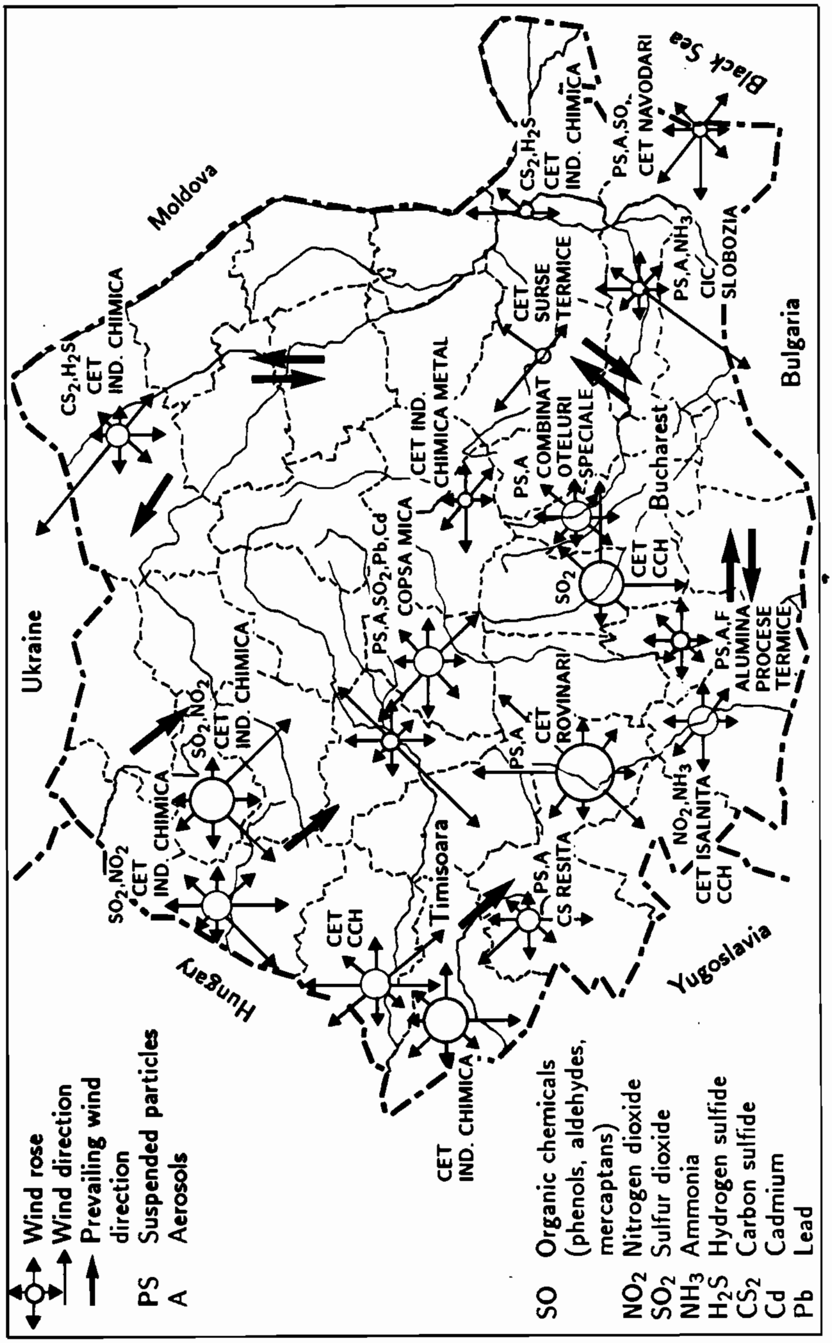

Figure 14.3. Air-quality problems in Romania.

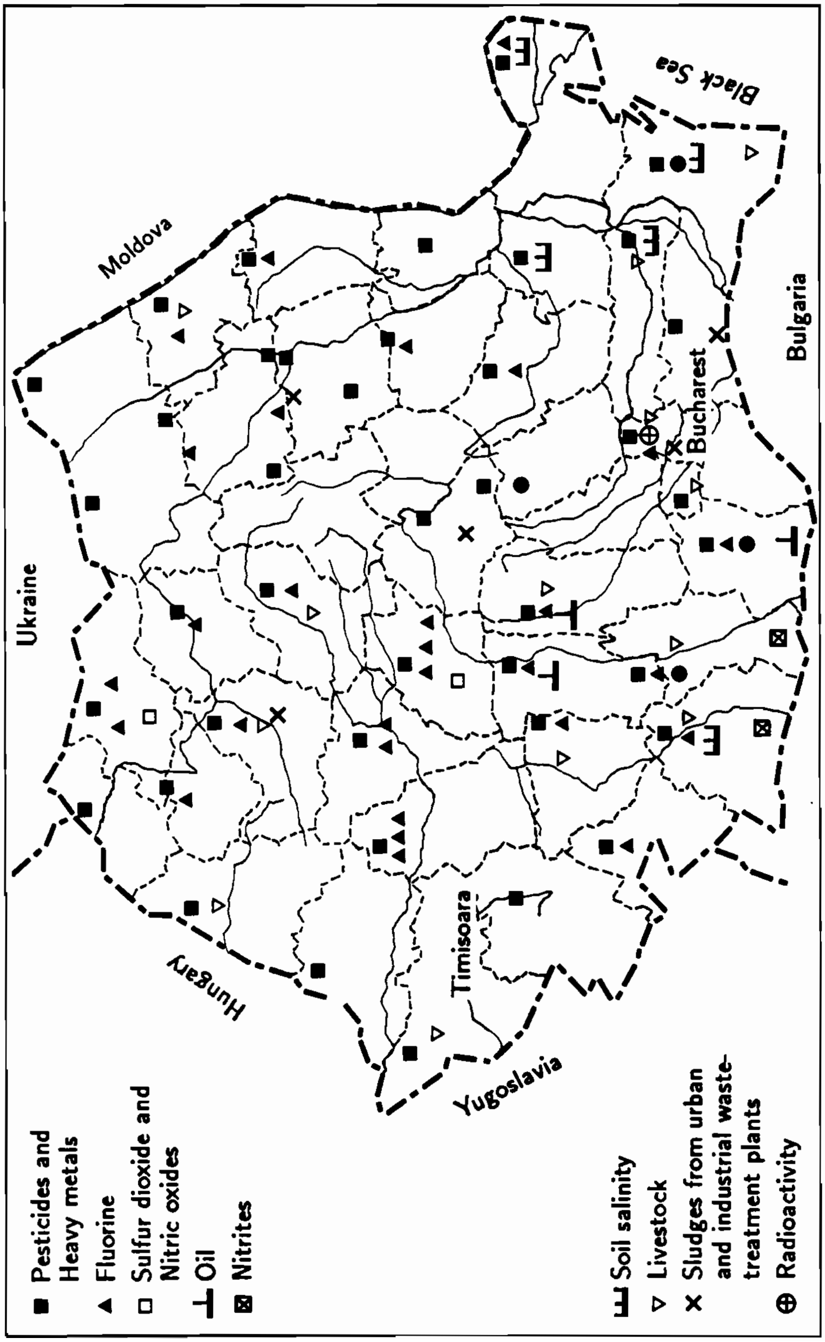

Figure 14.4. Soil-quality problems in Romania.

Slatina, Oradea, and Tulcea). Fluorine concentrations reached 300 ppm in some areas.

High fluorine concentrations were also found in soils around cement and cementing materials plants and even near power stations. The soils around cement and cementing materials plants are polluted by atmospheric heavy metals' deposition. These areas are Bicaz, Comarnic, Fieni, Hoghiz, Cìmpulung Muscel, and Tg. Jiu.

Agricultural lands are extensively polluted by the oil extraction industry. About 3,000 hectares of soils in the districts of Teleorman, Prahova, Brăila, Galaţi, Argeş, and Dìmboviţa cannot be used for agriculture because of oil pollution.

Among soil-polluting pesticides, organochloride compounds are especially persistent. In many cases concentrations of organocompounds of about 1 ppm were found, which is a very high value. Soils can also be polluted during irrigation by water from very polluted rivers like the Olt, Argeş, Mureş, Siret, Prahova, and Trotuş. This will be a major problem in the future.

Domestic and industrial wastes are sometimes used as fertilizer on agricultural land. About 0.022 million hectares are polluted in this way by 300 million tons of wastes.

14.4 Final Remarks

All environmental components (water, air, and soil) in Romania are seriously affected by pollution. An efficient solution to this problem is pollution prevention, which would diminish and even stop the deterioration in environmental quality. Pollution prevention measures are not easy to implement because they need special efforts and financing; nevertheless, they must be instituted. Wider cooperation is also necessary between all organizations and institutions interested in the development of a sound and unpolluted environment. It is worth every effort to fulfill this goal.

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Chapter 15

Priorities for Environmental Protection in Romania

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Conversion of a centralized political and economic system into a democratic and market-based system necessarily assumes the existence of an institution responsible for environmental protection and identifying priorities in this domain. Despite differences in the means used and the rate of the process, all Central and East European countries are moving in the same direction, and their priorities for environmental protection are similar.

Romania's priorities in environmental protection take into account the following points about the economy and environment:

- An unbalanced industrial structure (dominated by enterprises consuming large amounts of energy and raw materials) overexploits renewable and nonrenewable resources and relies on massive imports of raw materials (especially in the chemical and metallurgical industries).

- Many industries use obsolete technologies with no standards for monitoring efficiency or emissions.
- Important ecological systems are destroyed by pollution, lack of resources' management (irrigation, waterlogging, surface mining, and so on), and overexploitation of renewable resources.
- Legislation for environmental protection is rigid, inadequate, and ineffective.

Romania's priorities in environmental protection are also based on considerations and experience from systems ecology. The following points are of particular importance:

- Environmental protection is a fundamental precondition for sustainable development.
- Ecological systems are the structural and functional units of the environment (life-support systems); hence the objective of protection is to maintain their integrity.
- The support system of environmental protection should have an adequate structure and size to promote ecological reconstruction and to prevent perturbation effects.
- Environmental protection at the national level should be integrated with protection at the regional and global levels.

In Romania, high priority in environmental protection is given to both restoring damaged environments by removing the causes of ecological destruction and developing the knowledge and practice of sustainable development of resources. Special attention is given to the following activities:

- Classification of ecological systems (eco-regions) in Romania and assessment of their present state. This includes the identification of critical zones by degree of deterioration or by the intensity of pressures exerted upon them.
- Identification of causes of degradation and their anthropogenic components. This includes adopting effective remedial measures to attain environmental standards. It should be noted that this process is complex and influenced by both internal and external factors. Obviously, the speed and scope of this process of restoration depends

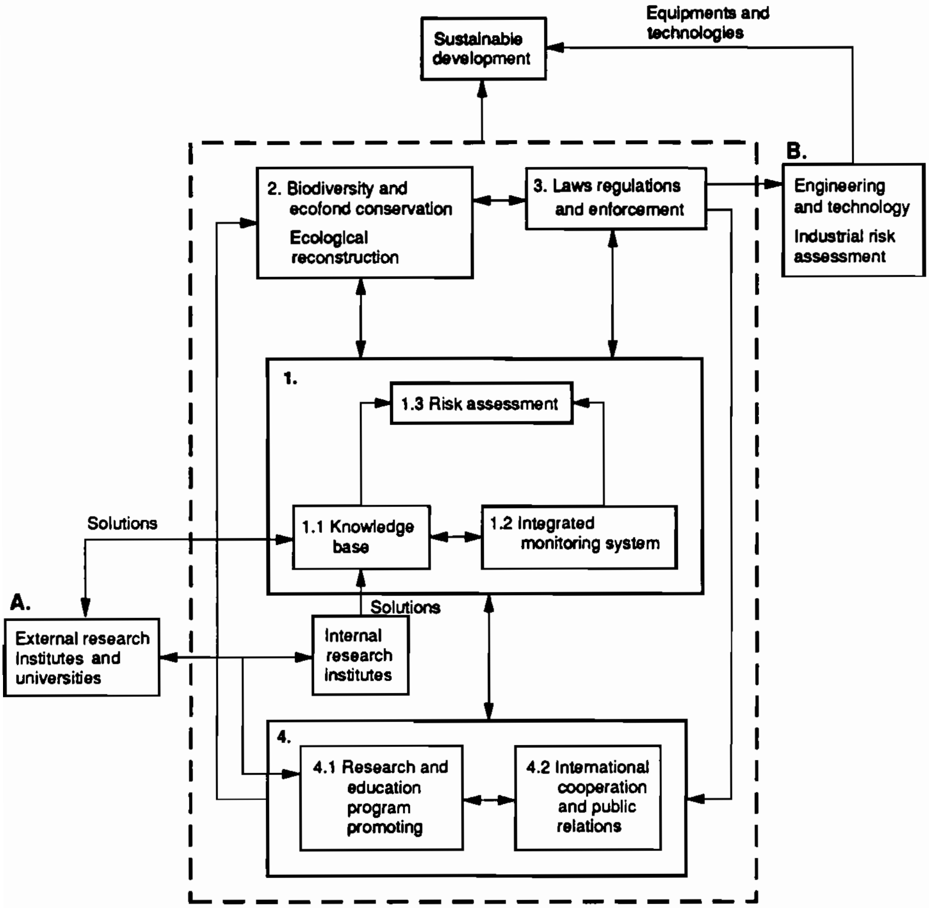

Figure 15.1. Structural model for environmental protection in Romania. Compartments A and B belong to the National Academy of Sciences and to other departments.

on expertise and on the country's economic and financial potential. Moreover, it depends on efficient technologies and accumulated experience, and especially on external financial support to supplement internal investment.

- Revision of the present structure of environmental protection (*Figure 15.1*). This should draw on global experience in the field with particular emphasis on studies at the national and transboundary levels.

- Improving the structure and functioning of all ecological systems (human settlements included) in Romania, including their productive and carrying capacities. A major priority for the 1990s should be to approach ecological problems in a systemic (holistic) manner, using programs correctly organized on a temporal and spatial scale. This knowledge will provide insights to help ecological reconstruction and risk analysis.
- Developing an integrated national monitoring system. This should include a network of stations covering all aspects of the environment with set standards of environmental quality and technology; this would become a part of a regional and global integrated monitoring system. The structuring and operation of this system, along with the knowledge base, will influence the effectiveness of risk analysis and the robustness of economic development strategies.
- Reforming environmental protection legislation and regulations. This includes adoption of the most appropriate international emissions standards as an intermediate phase, until the support capacity of ecological systems in Romania can be evaluated in detail.
- Development of a network of natural reserves and national parks (1.6% to 6% of the country's territory). This is necessary for preserving biodiversity and heterogeneity of ecological systems.
- Training experts in the field of environmental protection and public environmental education.

Keeping in mind these priorities in environmental protection in Romania, and recognizing that most are common to all Central and East European countries, we propose decisive actions to be initiated simultaneously which rely on multilateral cooperation. These actions also require substantial support from the European Community and other international organizations (OECD, EBRD, UNDP, UNEP, UNESCO, IUCN) involved in environmental protection at the regional and global levels:

- Coordinating recovery of national economies with the restoration of damaged ecological systems.
- Obtaining state-of-the-art equipment to monitor emissions from the energy, chemical, and metallurgical industries, as well as from agriculture, animal husbandry, and large towns. This would include access to better technologies and equipment and financial

aid and credits for environmental reconstruction, development, and protection.

- Development of a national system of integrated monitoring as part of regional and international monitoring systems. This would include obtaining standard measuring equipment, identification of standard indicators (including biological indicators), and installation of equipment for data processing and transmission.
- Development of a knowledge base (productive and support capacity) for large ecological systems, including scientific support for ecologically sustainable agriculture. The regions to receive particular attention should be the Danube and its basin (the Danube delta and the Black Sea) and the dying forests in the Carpathian Mountains.
- Training and education in ecology. This involves training in impact analysis, management of protected areas, and operation of monitoring systems.

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Chapter 16

The State of the Environment in Yugoslavia

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Yugoslavia is in a process of liberalization from a mixture of political doctrines that includes a kind of Marxist social compact and a hybrid centrally planned and market-oriented economy. These doctrines have been further modified to accommodate diverse nationalities, cultures, and religions among a population of some 23 million people. The estimated GNP of roughly US$2,500 per person per year (OECD, 1986) masks the great disparity between the western part (US$6,500) and the southeastern region (US$700). The last 45 years have also been a period in which some 6 million people, or one-quarter of the population, migrated from rural to urban areas. This transformation extracted a heavy toll on the environment and natural resources (ICIDI, 1980; Brundtland, 1987).

Environmental protection in Yugoslavia has been the subject of some 400 laws and 1,000 regulations (Yugoslavia, 1987). The number of

This chapter was written before the Civil War in Yugoslavia in 1991. Despite changes since then the article contains valuable information about this part of the world.

international conventions and protocols ratified has reached 37. However, there has been no unified approach to environmental protection and no federal authority is empowered to enforce laws, check quality standards, or recommend common criteria (Yugoslavia, 1987).

The constitutions of all the states contain provisions for protection of the environment, but the federal constitution provides only for the safeguard of "common interests." The definition of common interests has largely remained open.

16.1 Surface and Marine Waters

The quality of surface waters is critical in many areas, and generally unsatisfactory in all parts of Yugoslavia. The most pressing problem is the Sava River, the backbone of Yugoslavia, which originates in the subalpine region of northwestern Slovenia, flowing through the agricultural flatlands of Croatia and Bosnia before entering the Danube at Belgrade. Its watershed houses some 9 million people (40% of the total population); the area produces about 25% of total agricultural yield and 60% of total industrial output. On the basis of an average European biochemical oxygen demand (BOD-5) of 60 grams per person per day, the load to the Sava River is equivalent to 25 million people – that is a factor of 2.7 greater than the actual population. Most regulations require water quality that is rated category II. However, the Sava's water is mostly category III and in several places category IV.

The problem of agricultural runoff has been long recognized as a major threat to drinking-water supplies. However, little is being done since it would involve a profound change in agricultural policies. The flatlands of northern and northeastern Yugoslavia are the breadbasket of the country. The present yield of wheat crops (the 1990 average was almost six tons per hectare) is a result of intensive use of fertilizers, pesticides, and insecticides. The Danube-Tisa-Danube canal system is already showing signs of eutrophication as a result of overfertilization from agricultural runoff. Some significant freshwater lakes are already threatened. Agricultural runoff to Lake Bled, a small but important tourist resort in Slovenia, has been controlled to prevent eutrophication. The result has been far from satisfactory. A similar problem has occurred with Lake Palić near Subotica, a recreational facility in the province of

Vojvodina, near the Hungarian border. A cleanup effort that began in the early 1980s has almost completely failed because agricultural sources of pollution have not been treated effectively.

The major lakes of Macedonia, Ohrid, and Prespa also suffer from agricultural runoff. The problem at Lake Ohrid is aggravated by urban sprawl and recreational facilities built in recent decades. The lake is comparatively large (348 square kilometers), deep (maximum depth 695 meters), and well drained; thus its assimilative capacity is currently sufficient. However, if the Albanian part of the lake, which is now relatively undisturbed, were to be developed, serious bilateral measures would be necessary. Another type of problem confronts Lake Doiran (43 square kilometers, maximum depth 148 meters). Located in a basically arid region, its waters are used for irrigation. The droughts of recent years have resulted in excessive drainage of the lake causing an ecological catastrophe. Bilateral agreements between Yugoslavia and Greece have failed to alleviate the problem.

One concern of Yugoslavia is the protection of the Adriatic Sea. The framework of the Barcelona Convention and Its Protocols is the basis for action (UNEP, 1982; Kuwabara, 1984). Some 700 measuring stations monitor basic parameters of water quality, 170 of these in the Adriatic region. Data from 1987 indicate that Yugoslavia produces about 2 million tons of refuse per year. The management of toxic waste is largely unsatisfactory. The only operating incinerator is that of the VCM Works (a rated capacity of 200,000 tons per year, operating however only at 60% load) on the island of Krk, but this facility is for use only by the company.

Data indicate that the Yugoslav part of the Adriatic Sea is in an acceptable state, except for three hot spots: Kopar Bay, Rijeka Bay with Bakar Gulf as its most-affected point, and Kaśtela Bay near Split. Another factor leading to pollution of the marine environment is urban sprawl and the largely uncontrolled housing construction and tourism projects. Sewage- and wastewater-treatment facilities are lacking in new developments. Few wastewater-collection systems pump the sewage far out from the coast (Opatija in the north and the Klek-Ston region in the south).

Present legislation and quality standards strictly follow the recommendations of the World Health Organization and the EC (EC, 1976).

There is much interest in harmonizing Yugoslav standards of water quality and wastewater treatment with the directives of the Commission of the European Communities (CEC, 1988), mainly because of the overwhelming number of tourists from the EC countries.

16.2 Air Pollution

Air pollution is also a serious environmental problem. Use of indigenous, high-sulfur coal in many electrical power-generating stations is the major source of atmospheric sulfur dioxide. However, data indicate that although Yugoslavia is a net exporter of sulfur dioxide (estimated emissions in 1988, 1.65 million tons per year), acid rain in the alpine and subalpine regions and in the mountain regions of northwestern Croatia is mostly brought in by westerly winds from the northern Italian plains. In addition, the Chernobyl disaster and subsequent fallout of radioactive iodine and cesium 134/137 over the northeastern Yugoslav plains demonstrated that some air pollutants originate in the industrial regions of Eastern Europe (Poland, western Ukraine, the CSFR, and Germany).

Urban air pollution is very severe in major industrial towns, reaching critical limits several times a year, as in the case of the steel city of Zenica. Sarajevo has now embarked on a large program to convert solid fuel burners to natural gas, a technologically simple yet costly project that will ultimately involve 50,000 dwellings. Urban air pollution is also the result of some 2 million automobiles using leaded gasoline and high-sulfur diesel. Refineries still lack adequate capacity to produce unleaded fuel. The lead content of most gasoline produced in Yugoslavia exceeds the recommended upper level of 15 milligrams per liter. Ethylene dichloride is still a widely used additive. Monitoring for dioxins produced by urban traffic is rare, and reliable data are unavailable. Unleaded fuel is available only along the major international routes catering to foreign vehicles and costs about 10% more than standard leaded fuel.

Chlorofluorocarbons (CFCs) are widely used in Yugoslavia. Although Yugoslavia recently ratified the Montreal Protocol, no major decisions were made to eliminate the present consumption of some 30,000 tons per year. All household refrigerators and polyurethane foams made in the country use CFCs. However, because no CFCs are produced in Yugoslavia, the switch to acceptable alternative gases or solvents will remain a problem of the manufacturing companies (CEC, 1988). Vukmirović in Chapter 18 provides more information on air pollution in Yugoslavia.

16.3 Soil Erosion

Soil erosion is another major problem. Some investigators claim that about 7,000 hectares of prime agricultural land is lost each year through a combination of various factors: urban sprawl, land use for nonagricultural purposes including industrial plant siting and road building, acidification of soils by acid rain, mechanical erosion through lack of proper techniques of cultivation, and improper irrigation and lowering of the groundwater table. Although use of fertilizer in most agricultural regions is below the European average, there is no comprehensive plan to rotate crops or reduce pesticide use. In recent years forest fires have contributed to soil erosion in many Mediterranean countries, Yugoslavia included, and some reports estimate that 200,000 hectares of forests, vineyards, and olive groves are seriously damaged or destroyed each year. Since most of these fires are in the karst (limestone) regions of the Adriatic, the resulting soil erosion is nearly irreparable.

16.4 Regions of Specific Value: Natural and Cultural Heritage

National and nature parks cover 565,000 hectares (2.2% of the total surface area of Yugoslavia). Although protected from urban and industrial development, some unique natural areas (especially the Tara River Canyon, the Plitvice Lakes, and the Kornati Archipelago in the Adriatic) are visited by many tourists. The surrounding urban and rural settlements have an inadequate number of sewage-treatment plants and waste-management procedures to cope with this influx of tourists and tourism-related activities. The Tara River Canyon, the last virgin forest and river basin in Europe, has considerable hydroelectric-generating potential. Having banned further nuclear power development and having few fossil-fuel reserves, Yugoslavia will have to take hard decisions to preserve this natural beauty.

The Plitvice Lakes, a cascading system of 21 lakes carved by a river in a pure karst region, represent a fragile ecosystem. Limestone is sensitive to vibrational stress and also to wastewaters containing detergents. Although all vehicular traffic has been banned from the immediate vicinity and directed toward bypass roads, more than 2 million visitors arrive every year. Despite all precautions taken to treat wastewaters, some deterioration in environmental quality has been observed. However, since tourism accounts for up to 15% of Yugoslavia's GNP (OECD, 1986) and has been a major foreign currency earner, national and nature parks are an important economic issue and there is hope that action will be taken.

Being at the crossroads of ancient civilizations, Yugoslavia's cultural heritage bears witness to Greek and Roman civilization, exemplified by buildings of great historical and aesthetic value. The Roman arena in Pula and the palace of Emperor Diocletian in Split are just two examples of well-preserved architectural monuments. Several rare examples remain from early Christian times: the sixth-century basilica in Poréc; Gothic, Roman, and Renaissance buildings in Zadar, Nin, Trogir, Dubrovnik, Cavtat, and Kotor. The medieval monasteries in southern Serbia, Montenegro, and Macedonia are remnants of Byzantine cultural, religious, and architectural influences modified by strong indigenous elements. The Ottoman Empire has produced mosques in Sarajevo and Mostar. Many stone buildings are threatened by air pollution, mainly acid rain. Fierce land-use pressures, reconstruction of towns, and road traffic have contributed to the gradual erosion and destruction of these monuments. The thirteenth-century cathedral in Trogir is in the path of aircraft taking off and landing at the nearby airport and shows signs of vibration-induced structural failure. The problems here are similar to those facing Venice and Athens. However, in times of economic crisis and investment austerity, there is little chance that conservation measures will be sufficiently funded, although the technologies required are known.

Most industries in the region should be retrofitted with equipment that produces relatively low emissions of air pollutants such as SO_2 and NO_x. Road traffic should be reduced and diverted to alternative roads in less critical regions. Last but not least, strict noise and exhaust controls should be imposed on vehicles.

16.5 Environmental Management Strategy

Yugoslavia requires a harmonized plan for environmental protection that takes into account the diversity of its peoples and landscapes. Such a plan, inspired by the ideas of Holling (1978), Stigliani *et al.* (1989), and the Environmental Impact Assessment procedures used in many countries (Mayda, 1982; NRC, 1986), has been submitted to the Yugoslav government (Strategy, 1990). There is no doubt that any plan should take into consideration the two major regions Yugoslavia belongs to: the Central European region along the Danube River and the Mediterranean region, of which the semi-enclosed Adriatic Sea is an important part. In the first case, present thinking in Yugoslavia closely follows the framework of the Fourth Environmental Action Programme of the European Community (EC, 1987). In the second, activities are based on the Mediterranean Action Plan framed by the Barcelona Convention and Its Protocols, particularly the Protocol on Land-Based Sources of Pollution.

Unfortunately, these two programs are in themselves not fully harmonized. The EC program is both *substance* and *source* oriented whereas the Barcelona Convention's Protocol on the Land-Based Sources of Pollution is predominantly substance oriented (despite its title). The latter strictly follows the Paris Convention (Anon, 1974). It is important to note that the eutrophication problems in the northern Adriatic can be dealt with only by a source-oriented environmental pollution-control program.

Unfortunately, because of more pressing political and economic problems the strategic plan (Strategy, 1990) for dealing with Yugoslavia's environmental problems has been sidetracked. Nature will have to wait for the betterment of human relations.

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Chapter 17

The Yugoslav Long-Term Policy for Environmental Management

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The relationship between environment and development is one of the many concerns of the Club of Rome. Limitations to growth, real or imagined, are a perennial topic of discussion among international groups, nongovernmental organizations, and governmental executive and advisory bodies. Thus, rather than repeat issues and recommendations of a general nature, this chapter aims at describing the emergence of environmental management policies in Yugoslavia, a European country in transition from a state of low to intermediate development. This paper was written on the eve of profound changes in the political, economic, and social structures of the country. Although it reflects contemporary trends in Europe, particularly in the European Community, represented

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This chapter was written before the Civil War in Yugoslavia in 1991. Despite changes since then the article contains valuable information about this part of the world.

by the Fourth Environmental Action Programme of 1987–1992 (EC, 1987), it also is a description of environmental management and of some ideas advanced by Mayda (1985a). Mayda describes environmental impact assessment studies as a contemporary tool of *social* technology.

17.1 The Background

Environmental management in Yugoslavia has lagged behind environmental concern in many countries, those of Europe included. Some of the East European states, from the CSFR to the former European USSR, seriously neglected environmental protection in a vain effort to achieve fast industrial growth. Recent events have demonstrated the futility of such development – development which left behind a severely polluted and degraded environment in Europe for future generations to cope with. It may be of interest to analyze in this context the situation in Yugoslavia, a country which, until recently, had a unique form of non-market economy and an environmental management system regulated by a complicated social structure.

Geographical, natural, geological, and climatic variations are surprisingly large for a country with an area of 250,000 square kilometers. Four main regions have been identified: the flatlands in the watershed of large rivers (Danube); mountainous regions (alpine in the west, central Dinaric range, Balkan mountains in the southeast); the karst region, spreading from northwest to the southeast; the Adriatic Sea and its islands. Each region requires a different environmental management strategy.

17.2 The Environmental Diagnosis

In spite of successes in combating pollution and regulating new industrial and urban development, environmental protection measures have not been very effective. The laws in the various federal states are far from harmonized, there being no common environmental quality standards for Yugoslavia (except where international standards apply, such as those prescribed by WHO). The administrations in the federal states have been neither organized nor properly equipped. There have been no selective regional development plans, and the international conventions and protocols already ratified have not been effectively enforced. The present economic difficulties and efforts at administrative reorganization have only aggravated the unsatisfactory state of environmental management.

The Federal Coordinating Council for Environmental Protection, a consultative body without enforcement powers, identified many of these problems in 1988. A declaration in the form of a social compact (Assembly of Yugoslavia, 1987), the usual form of recommendation for action to the federal administration, resulted in a diagnosis of the state of the environment (Federal Coordinating Council, 1989). The report revealed a serious lack of agreement among the states on common environmental policy and joint action. Efforts to reorganize the country, both administratively and economically, fall short in this respect.

The drafting of a long-term strategic plan was initiated to address these problems (Strategy, 1990). The plan is intended to be the basis for modifying sectoral development measures (e.g., energy, transport, agriculture, forestry, and urban development) and a comprehensive blueprint for restoration of environmental quality in the most critically endangered regions. The Rudjer Bošković Institute in Zagreb, an independent scientific research institution, acted as a consultant to the federal government in drafting this plan. A team of experts prepared a draft document of the plan, which was to be submitted to the federal parliament for adoption after a broad-based public debate. The strategic plan uses so-called third-generation strategies as its basis.

17.3 Three Generations of Environmental Strategies

The first generation of strategies was introduced in the 1950s and 1960s when most of the technologically developed nations (the United States, Canada, and Western Europe) realized that they could no longer ignore the environmental costs of their policy (sometimes called the "primitive strategy") to dump untreated wastes in waters and to emit pollutants into the atmosphere. Inland waters and the oceans were the first to show signs of degradation that required systematic remedial measures. Air pollution in the UK, the USA, and West Germany also indicated that the use of low-grade, sulfurous fossil fuels exacts an environmental price which soon impedes further development in large industrial basins. It should be noted that two decades later the situation was much worse in Eastern Europe in countries with centrally planned economies.

Most of the examples described in this chapter refer to the marine environment, an area where the need for international cooperation is readily recognized. However, the same condition holds for environmental management and preservation of land, soil, air, and inland (surface and ground) waters.

The first generation of strategies relied on laws and penalties to restrict pollution. The *polluter pays* principle was used, with some success, to enforce these laws. The principle was applied through the following means: black and gray lists of substances (B/G); uniform emission standards (UES); the concept of best technological means available (BTMA); and the concept of best practicable means available (BPMA).

Regulations based on the black and gray list of substances were favored by the UNEP-sponsored Regional Seas Conventions (UNEP, 1982a; UNEP, 1984; Kuwabara, 1984), the Paris Convention (Anon, 1974), and other international agreements. They followed the same conceptual approach and stated that substances listed in the black list should be prohibited from reaching the marine environment and those in the gray list should be subject to licensed and controlled releases. These well-intentioned regulations are ineffective if one recognizes that urban sewage usually contains unknown amounts of any or all the substances from the black list. A typical example is the case of cadmium, prominently displayed on the black list. This highly toxic metal is still widely used in protective metal coatings and certain kinds of batteries. Cadmium from these sources, particularly from discarded batteries, ends up in urban sewage. Thus there is no safe, substance-oriented regulation by which cadmium can be effectively prevented from reaching the environment. Only source-oriented regulations can stop this pollution by mandating the substitution of cadmium in batteries and protective coatings for other more environmentally friendly materials.

Uniform emission standards have most prominently been advanced by the European Community. The standards are based on Council Directive 76/464 (EC, 1976). This directive requires similar industries to have comparable pollution-prevention standards to ensure equal economic conditions throughout the Community. However, it neglects the sensitivity of specific environments to pollution, so equal economic opportunity has been largely a matter of taxes and salary scales rather than environmental protection measures.

The concepts of BTMA and BPMA are fairly good regulatory mechanisms, although they primarily consider what is available or practicable for industry rather than what is needed to preserve environmental quality. These concepts were incorporated into many international conventions and were considered adequate by most industrialized nations at a time when the level of industrial pollution worldwide was still low (or rather, unrecognized). One reason for the early popularity of these regulations was their apparently clear-cut enforceability.

Ocean dumping of hazardous waste was curtailed by the implementation of first-generation strategies. The safety of shipping, especially bulk oil carriers, has increased considerably through changes in ship design and improvement of port facilities. This favorable, but limited, achievement is recognized to be important for Yugoslavia in protecting the Adriatic Sea. Although never the panacea hoped for, environmental management of natural resources using first-generation strategies within Yugoslavia showed good results, particularly in regions or cases where pollution was excessive.

International waterways continue to pose the severest problems, particularly the Rhine and the Danube. Lengthy negotiations were needed to agree on international effluent standards to ensure acceptable water quality in the lower Rhine in the Netherlands or the Danube in the Balkans.

With the advancing integration of the Common Market in Western Europe, the enforcement of uniform emission standards might generate suitable technological solutions of effluent treatment. However, an international impasse exists – particularly in the case of the forest and pulp and paper industries; no individual company is willing to invest in pollution control unless its major competitors do the same. This has been documented in case studies of these industries in Finland (OECD, 1988), Canada, and the United States (NRC, 1986). Let us critically examine the suitability of some of these regulations to Yugoslavia's case.

First, the feasibility of identifying and estimating the quantity of substances in the black list (whose disposal or dumping into waters and seas is prohibited) in urban and industrial waste is doubtful. For this reason, end-of-the-pipe strategies simply do not work. Second, uniform emission standards have been instituted almost everywhere in Europe, Yugoslavia included, but their usefulness and strict enforcement are doubtful. For example, coastal regions of the Mediterranean Sea have far more sensitive and critical environments than some parts of the continental land mass (UNEP, 1982a). For this reason, less-than-adequate emission standards would cause rapid deterioration of the coastal regions and some particularly valuable environments. Conversely, enforcement of strict standards nationwide would impose high costs on certain vital industries (such as power production, oil exploration and refining, or urban sewage disposal).

First-generation strategies were oriented to industry and not to the environment. They were regarded as a major concession of industry to the public good and represent the first systemic approach to pollution abatement.

The second generation of strategies was introduced in the late 1960s and the early 1970s in the wake of the 1969 National Environmental Protection Act (NEPA) of the United States (CEQ, 1978) and the Stockholm Conference of the Human Environment of 1972 (UNEP, 1982b). Economic stimuli were gradually added to first-generation strategies. Various techniques were used: tax incentives, development credits, and (in the case of some less developed countries, Yugoslavia included) waiving of custom duties for imports of pollution-abatement gear. These are the ways and means by which governments tried to overcome the serious difficulties of implementing environmental quality objectives.

The *polluter pays* principle has occasionally been subverted to that of *he who pays is licensed to pollute.* This was particularly the case when national assemblies would not impose really stiff, neck-breaking penalties for violation of environmental laws. This was the prevailing attitude in Yugoslavia and in the many countries of Eastern Europe (more precisely, in the centrally planned economies). Some European and African countries have even accepted foreign toxic waste against payment.

Until now reference has only been made to the measurable effects of pollution in water, air, and soil. Losses in human health, aesthetic values, and cultural wealth as a consequence of widespread pollution are harder to quantify. For example, the damage to classical Greek and

Roman buildings in the greater Mediterranean region, or whole cities like Venice, is almost irreparable.

Second-generation strategies are also industry oriented and have generally failed to implement preventive measures in major problem areas. Political and military confrontations have kept protection of the environment very far down the list of priorities. Similar observations are valid for some market economies if one considers the price Japan and some newly industrialized countries in Asia and Latin America have paid in terms of environmental degradation. One can immediately see that a market economy is not a panacea for environmental problems.

An important feature of second-generation strategies is the introduction of Environmental Impact Assessment (EIA) procedures (CEQ, 1978; Heffernan and Corwin, 1975; Beanlands and Duinker, 1983). EIA has been strongly influenced worldwide by US practice. In many cases EIA procedure has never exceeded either the format or the regulatory level of what should be more appropriately called an ecological study, a *post-facto* assessment of impacts on the natural environment (Croatia, 1984). There is some value to this approach, in that the most obvious, local, and minimal measures to mitigate the worst pollution have usually been implemented. That the EIA process is, or must be made, a comprehensive instrument of environmentally sound economic development, as proposed by Mayda (1978, 1982, 1985a, 1985b, 1986a, 1986b), has reluctantly been accepted. The successful implementation of these ideas requires another significant step, the *third generation* of strategies.

Third-generation strategies were devised in the 1980s from concepts of comprehensive environmental management, source-oriented and anticipatory measures, and the new allocation of resources, including air, water, and soil. The ideas have been most explicitly described in three documents.

The first of these is a report issued by IIASA which introduces the concept of *adaptive environmental management*, a radical departure from the deterministic concepts inherent in the prevailing approach to environmental management in the USA (Holling, 1978). At the same time the North–South Commission indicated the widening gap between rich and poor nations, anticipating their desperate efforts to develop at any cost (ICIDI, 1980). Deforestation in Africa and clear-cutting of tropical rain forests in Latin America are among the most critical consequences of such development.

The second document is the controversial GESAMP report entitled *Environmental Capacity* (GESAMP, 1986). It embraces the idea of a final capacity of the environment to accept and deal with contaminants. This capacity, known as *assimilative capacity* in literature on human toxicology, was identified in the 1970s as a term in ocean management by Goldberg (Goldberg, 1979). It has also been termed *receiving capacity* and translated into ambient air criteria in air-pollution management. The concept recognizes the need to dispose of waste in a way that minimizes harmful pollution. A profound change was brought about in the 1980s by the emergence of environmentally friendly technologies and the gradual phasing out of products whose technologies were unable to cope with the requirements of environmental protection.

The third document developing the concept of comprehensive management (or "integrated planning" in countries which use medium-term economic plans) is the report on the best practicable environmental option (BPEO) of the Royal Commission of the Environment of the United Kingdom (Royal Commission, 1988). The design of this option has been significantly influenced by the management principle discussed in the early 1980s in the Federal Republic of Germany: *The Vorsorgeprinzip* (Feldhaus, 1980). All three documents indicate the change to source-oriented concerns in environmental protection.

The search for a BPEO recognizes that industrial civilization will continue to produce waste, although possibly much less in the future, and that waste disposal can be rationalized only if the environment is considered both globally and in terms of the interaction between its major media: air, water, and soil. The search for a new option has been motivated by several converging needs:

- The need to find an acceptable option for the disposal of high-level long-life radioactive waste.
- The need to reduce the burning of fossil fuels and the deforestation of whole continents, which will enhance the greenhouse effect and might cause global warming.
- The need to protect the oceans from indiscriminate dumping of all kinds of waste, particularly urban.

- The need to prevent the depletion of stratospheric ozone by chlorofluorocarbons (CFCs).

The BPEO report is important for the development of long-term environmental policy because it stresses the need for a new type of environmental impact assessment study, basically along the lines advocated a decade earlier by Mayda (1978).

No document has had a more profound impact on environmental thinking than *Our Common Future* (Brundtland, 1987). For all its shortcomings and obvious compromises, it clearly states that the problems of today can only be solved by a comprehensive economic, political, and social approach. The report advances the concept of sustainable development, now widely accepted, but falls short in describing how to apply it. It shows that an era of scientific philosophy has come to an end. The sciences can provide knowledge, and technology can provide tools; humanity's task is to make the right economic, social, and political decisions to use them.

17.4 The Yugoslav National Strategy: Aims and Limitations

In the last 20 years the need for quick, effective environmental solutions has resulted in some 400 laws and about 1,000 local, regional, state, and federal regulations (Federal Coordinating Council on the Environment, 1989). Unfortunately, many of these regulations were based on the dispersion of pollutants and have often led to contradictory goals. For example, administrative ineffectiveness and legal obstacles to the designation of areas for solid-waste disposal have resulted in their being located all over Yugoslavia. Leaching of wastes from widely scattered waste-disposal sites has led to contamination of aquifers and the water supply of some urban areas.

The choice was either to use second-generation strategies (combining prohibitions, licensing procedures, penalties, and tax incentives) or to go a step further and use third-generation strategies to introduce a legal framework for comprehensive environmental, economic, and political planning in development projects. This issue was anticipated by Mayda (1985a) several years ago.

In 1989, a year of turmoil and change in Eastern and Southeastern Europe, all indicators pointed toward implementation of the more advanced concepts. However, the economic and technical capacity to apply advanced concepts is doubtful. Enforcement authority suffers from lack of trained personnel. In addition, large differences in economic standing between regions of Yugoslavia favor a flexible transition strategy which combines second- and third-generation approaches. A mosaic of regulations has been drafted which, if consistently applied, will produce the result desired. Also, the *Strategy* is based on a firmly established hierarchy of interests and aims, with broad-based interests predominating over individual or group interests. This is important to counteract pressures from various development or industry lobbies and from environmental groups advocating their own, narrowly defined goals. One crucial aspect is the preference given to long-term solutions over short-term ones.

17.5 Structure of the Strategy

The final document consists of 53 measures (including guidelines and tasks), subdivided into 9 groups specifying *how, why, who*, and *when.*

1. The first group of measures deals with policy making, including legislative and administrative tasks. Included in this group is the recommendation that a basic environmental law (in the spirit of NEPA) be written. The purpose, format, scope, and production of environmental impact assessments is outlined in these measures. They also deal with the division of responsibility among federal and state authorities.
2. The next group of measures deals with economic and financial regulations and establishes environmental protection funds at the state, and later at the federal, level. Strict limitations are suggested for these funds. Money is to be collected by taxing users and abusers of natural resources.
3. The group of technical and technology measures addresses both producers and users of potentially polluting products. New environmentally friendly technologies are recommended, as well as strict adherence to environmental standards. These measures emphasize

the need for product performance standards that are environmentally friendly rather than merely economically advantageous. Transport of dangerous substances falls into this group.

4. The group of measures regarding space (land-use) planning and management introduces new concepts in physical and urban planning, increasing their scope to include the assessment of environmental carrying and assimilative capacities. National and natural parks, important for biological preservation of animals and plants, are dealt with by this group of measures. The Adriatic Sea, the islands, and the coastline receive special attention.
5. The group of measures having to do with an information system recommends the establishment, use, and application of databases and models for decision making. Free access to all environmental data, irrespective of their economic or political implications, is recommended. This is in line with the recommendation of the Commission of European Communities on the need for a freedom of environmental information act.
6. The measures regarding scientific research recommend public support to improve environmentally oriented research, monitoring, and development of new management techniques.
7. Training and education measures aim to address a weak point of the environmental management structure: lack of professionally trained personnel. Education at all levels to create public awareness of environmental issues is an additional goal.
8. Measures concerning public information aim to improve media coverage of environmental issues, as well as assist professionals in communicating environmental information to the public.
9. Measures regarding the international dimension of environmental protection and management include the recommendation that Yugoslavia should adopt relevant international conventions and protocols on environmental protection; in addition, Yugoslavia should implement these measures as soon as possible. Bilateral agreements (like the protection of the Adriatic Sea with Italy), regional agreements (like the Barcelona Convention), and global agreements (like the Convention of the Law of the Sea and the Basel Convention) are interpreted as separate but interconnected tasks in a comprehensive approach to environmental management.

17.6 Conclusion

The implementation of the ideas on environmental management developed in the 1980s seems possible. It will be difficult, in the face of emerging public awareness of environmental issues, to continue in the old ways. Yugoslavia is a microcosm of Europe. Many of its problems have been aggravated by the common malaise of political interference in areas where market forces would certainly do better, as in the economic system and technological development, and noninterference in areas where the intervention of the government as the guardian of common causes, as in environmental protection, seems desirable. The drafting of a long-term plan in Yugoslavia should therefore be considered a test of whether a plan for comprehensive environmental, economic, social, and technological development is workable in a country in transition. The plan would also serve to define the applied concept of sustainable development.

Acknowledgment

The ideas expressed and the *Strategy* itself are in line with the activities and ideas of the Club of Rome. The main difference is in the target audience: the Club of Rome writes reports to itself and the world tries to look over its shoulders; the *Strategy* was written for the national policy makers in Yugoslavia.

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Chapter 18

Air-Pollution Problems in Yugoslavia

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According to official statistics over 6 million Yugoslavian farmers abandoned agricultural activities between the end of World War II and 1981 (FMD–EPD, 1990a). Urban population more than doubled during this period. The rate of industrial growth that accompanied this change was high, especially in electric-power generation (10.5% per year). However, growth in national income has not followed this expansion. On the contrary, public assets have been depleted by overuse of energy and other natural resources. The state is overloaded with credit obligations, and damage to the environment is evident. Despite efforts to institute sanctions, the government has not succeeded in checking environmental degradation.

Yugoslavs are now faced with the problem of deciding for themselves how to manage this legacy of the postwar years. One response has been

This chapter was written before the Civil War in Yugoslavia in 1991. Despite changes since then the article contains valuable information about this part of the world.

a draft environmental protection strategy (FMD-EPD, 1990b), which has been distributed to the governments of the republic.

Low-growth industries with a poor history of environmental control are a major cause of environmental problems. These industries also operate in urban areas with scarce funds for pollution control. These low-income urban areas require some kind of outside assistance for environmental protection. Some local communities have managed to organize acceptable environmental monitoring, for example, Zenica (Bosnia and Herzegovina), Pančevo, T. Mitrovica, and Bor (Serbia), and Rijeka and Split (Croatia). Slovenia has always had a very advanced approach to solving environmental problems.

18.1 Ambient Air Quality

Because of cost considerations, Yugoslavia has opted for a relatively inexpensive system of monitoring air pollution by using existing stations. The administration of most of the 136 meteorological stations and 126 sites is centralized under the jurisdiction of public-health institutes.

Belgrade was covered by two monitoring sites in 1953. By 1976 the network was extended to 15 sites. Methodology recommended by OECD is used to determine SO_2 and smoke in 24-hour air samples (OECD, 1964). One site with SO_2 automated measuring has been functioning at the Meteorological Observatory on Vračar (*Figure 18.1*, area 1). Because of poor maintenance and bureaucratic delays in the purchase of parts and calibration permeation tubes, this site did not accomplish the percentage of measurements required for such a station (95%).

The situation is completely different in Slovenia. A systematic research program has been established by the Jožef Stefan Institute and the Institute for Power Economy and Electrical Industry. The program includes a sophisticated on-line monitoring system of six stations and a mobile laboratory. This system measures meteorological parameters, radioactivity, and levels of SO_2, NO_x, and O_3 every 30 minutes.

The Rudjer Bošković Institute in Zagreb provides measurements of ozone concentration. Its automated stations also contribute to the WMO Global Watch Program and TOR subproject of the European EUROTRAC project (Božićević *et al.*, 1976; Cvitaš *et al.*, 1979; Klasinc, 1990). For the purpose of air-pollution research in Serbia, temporary

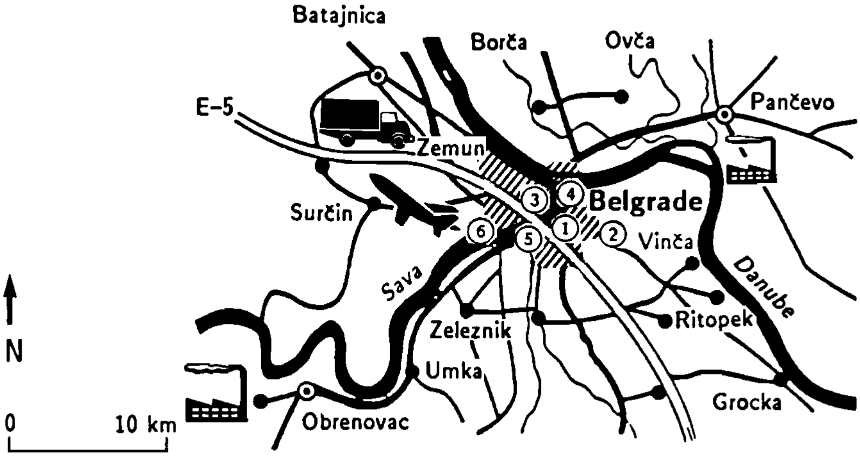

Figure 18.1. Traffic network and sampling sites in Belgrade: 1 Vračar; 2 Zeleno Brdo; 3 Mostar; 4 Dorćol; 5 Banovo Brdo; 6 New Belgrade.

monitoring of photo-oxidants in the atmosphere of Belgrade has been organized in the network presented in *Figure 18.1* (Vukmirović *et al.*, 1987). In addition, radioactivity and ozone radiosounding measurements were taken in Belgrade in 1990.

A comparison of air quality in the capital cities of the republic was carried out in 1987 at the urging of the editor of the journal *Protection of the Atmosphere.* As a result, longitudinal sets of SO_2 and smoke concentrations in 24-hour air samples were compared.

Some encouraging scientific research is taking place in Yugoslavia; this includes the research on total suspended particles and heavy metals being conducted at the Institute for Medical Research, Zagreb, and the cooperative work between the Republic Hydrometeorological Institute and the "Boris Kidrič" Chemical Institute in Ljubljana (Bizjak *et al.*, 1988a, 1988b). There also are occasional inspections of pollutant emissions from vehicles in Belgrade, Zagreb, Skopje, Novi Sad, Sabac, and Kraljevo (FMD-EPD, 1990a).

Yugoslavia has maintained EMEP stations since October 1977 and is helping to implement the fifth phase of this program (FHI, 1990). Locations of the EMEP stations in Yugoslavia are presented in *Table 18.1* (Ristić *et al.*, 1989). All stations are situated in mountain areas.

Table 18.1. EMEP network in Yugoslavia.

EMEP abbrev.	Station Name	Coordinates	Altitude above mean sea level (m)
YU 1	Mašun	45°39' N 14°22' E	1,026
YU 2	Puntjarka	45°54' N 15°58' E	988
YU 4	Zavižan	44°49' N 14°59' E	1,599
YU 5	Kamenički Vis	43°24' N 21°57' E	813
YU 6	Ivan Sedlo	43°46' N 18°02' E	970
YU 7	Lazaropolje	41°32' N 20°42' E	1,332

Table 18.2. SO_2 and NO_x emissions in Yugoslavia, in 1,000 tons per year.

Emission	1980	1981	1982	1983	1984	1985	1986	1987	1988
SO_2	1,175	1,300	1,300	1,400	1,450	1,500	1,500	1,550	1,600
NO_x (as NO_2)	350	360	370	370	380	400	420	440	480

18.2 Emissions of Air Pollutants

The lack of East European emissions data is a large source of uncertainty in modeling transport, transformation, and deposition of atmospheric constituents on the continental scale. The validation of SO_2 and NO_x emission measurements in Yugoslavia is performed by the national authority, and the data are sent to the European Community and EMEP Meteorological Synthesizing Centers – West and East (FMD-EDP, 1990a).

Current modeling needs call for an emission inventory with good spatial and temporal resolution. Data from Knežević (1990) on SO_2 and NO_x are presented in (*Table 18.2*). Estimates by Pacyna (1989) for 1982 of 1,314,000 tons per year of SO_2 and 440,000 tons per year of NO_x as NO_2 are close to those in *Table 18.2*. However, Knežević's estimates of the spatial distribution of SO_2 (*Figure 18.2*) differ from Pacyna's estimates (*Figure 18.3*).

Yugoslavia has ratified the Convention on Long-Range Transboundary Air Pollution but refrained from signing the SO_2 and NO_x Protocols of this convention. Taking 1980 as a reference year, we can compute that the total imported sulfur depositions were 625,000 tons per year and 502,000 tons per year in 1980 and 1988, respectively, and total sulfur

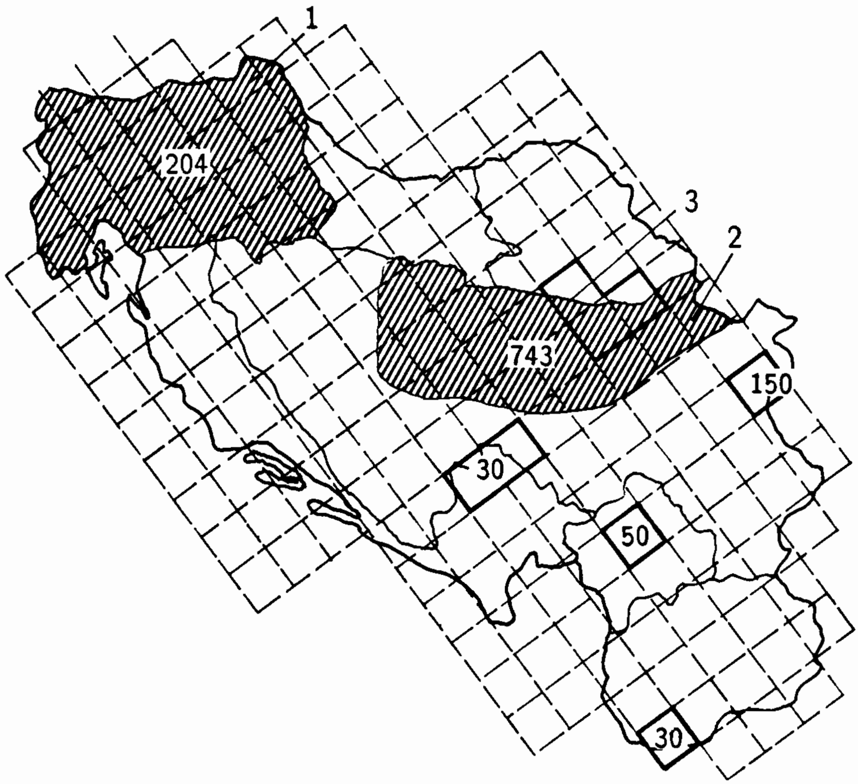

Figure 18.2. Areas of high SO_2 emission density in Yugoslavia, in 1,000 tons per year, in 1988. The data in areas 1 and 2, as well as in the rectangles, are taken from Knežević (1990). Area 3 contains high SO_2, NO_x, VOCs, CO, and NH_3 emissions.

exports were 364,000 tons per year and 370,000 tons per year in 1980 and 1988, respectively. Corresponding estimates made for nitrogen compounds in 1985 and 1988 indicate that Yugoslavia imported four times the amount of nitrogen than it exported.

The leveling off of the amount of sulfur exported is unusual because of the significant increases in SO_2 emissions which have occurred (*Table 18.2*). For example, estimated emissions for the TPP-NT facility in Obrenovac near Belgrade (*Figure 18.1*) were 170,000 tons per

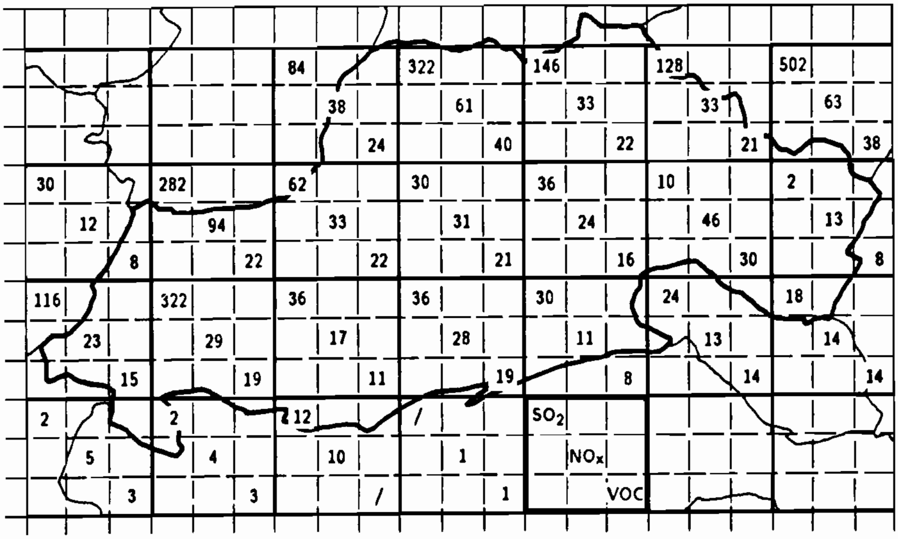

Figure 18.3. Spatial distribution of SO_2, NO_x, and VOC emissions in EMEP grid of 150 km × 150 km, in 1,000 tons per year, in 1982. Source: Pacyna, 1989.

year in 1988 (Knežević, 1990). Energy production here doubled between 1980 and 1988 (*Figure 18.4*); this alone contributed an estimated 10% increase in total SO_2 emissions in Yugoslavia. It is surprising that neighboring Romania and Hungary have not registered an increase in S deposition. More research should be directed to study this. Preliminary investigations indicate heavy deposition of S compounds in the Obrenovac-Belgrade-Pančevo air basin (Vukmirović, 1988).

Yugoslavia is preparing to start a volatile organic compound (VOC) inventory in compliance with OECD requirements. Major sources of VOCs are concentrated in the Obrenovac-Belgrade-Pančevo air basin; these include a polyvinyl chloride (PVC) production facility and an oil refinery in Pančevo and an organic chemical factory that produces toluene diisocyanate (TDI) located between Obrenovac and Belgrade (*Figure 18.1*). Both ethylene and toluene have high potential for photochemical ozone formation (Derwent and Jenkin, 1989). The proximity of large cities, where surface and elevated inversions occur, together with

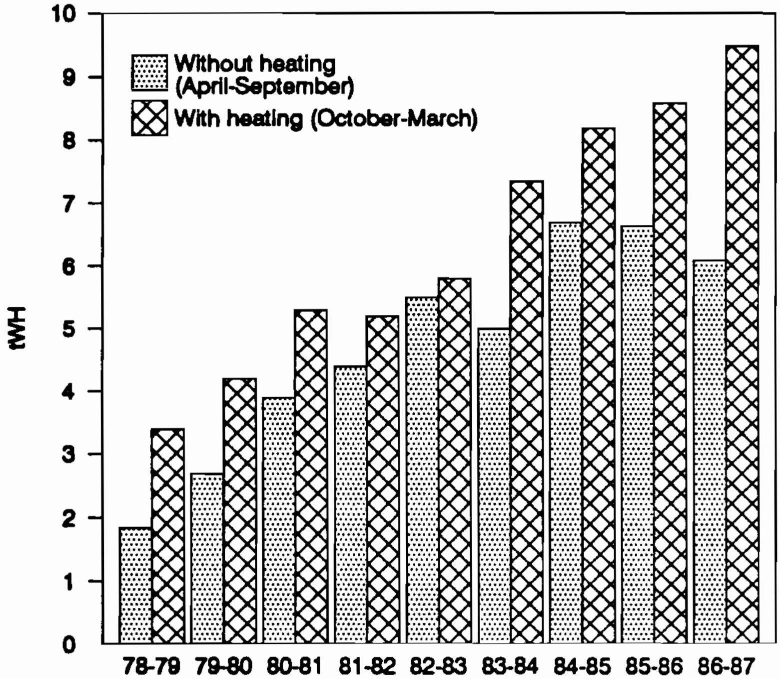

Figure 18.4. Energy production from the TPP NT facility at Obrenovac by seasons with and without heating.

complex topography and heat island effects probably contributes to the deposition of primary and secondary pollutants within the territory of Yugoslavia (Vukmirović *et al.*, 1990a).

18.3 Transport of Air Pollutants

Yugoslavia is a country of large contrasts in topography and climate and therefore attracts many tourists. Clean air is maintained in mountainous areas (Ristić *et al.*, 1989). Air quality is also good along the sea coast, except in Split and Rijeka (*Figure 18.5*). However, many mistakes have been made in land use in the foothills of some mountains.

Stagnation of polluted air not only originating from Yugoslav industry but transported long distances is a normal occurrence in low lying areas (Petkovšek, 1987). For example, the copper mine and smelter in

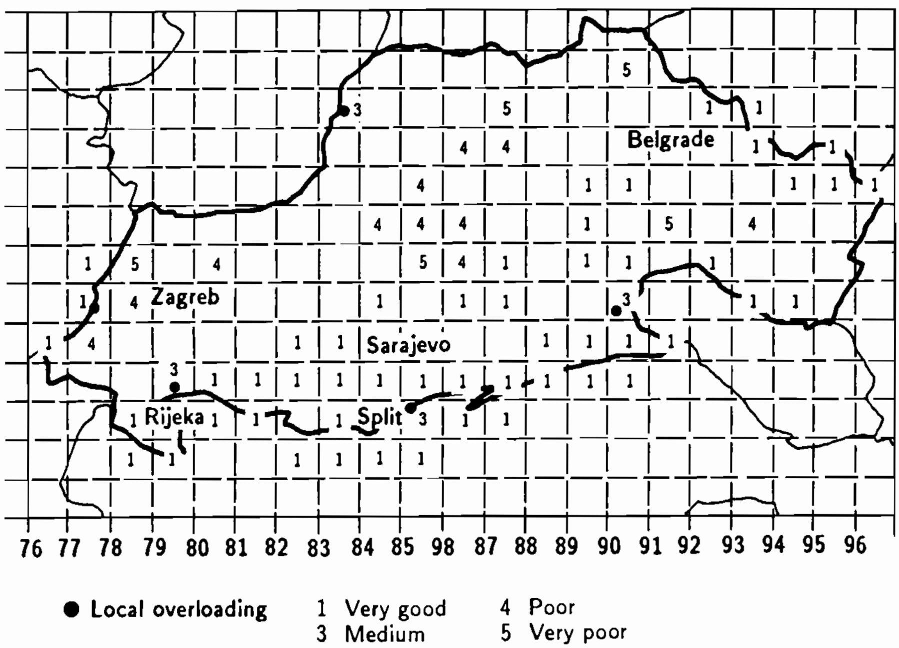

Figure 18.5. Air quality in Yugoslavia.

Bor is situated in a deep valley and the dispersion of its large SO_2 emissions (150,000 tons per year) is blocked not only by the valley walls but also by an enormous mound of solid wastes.

Short-range transport modeling has been carried out in Yugoslavia by various organizations (Republic Hydrometeorological Institute, Center for Meteorological Research and Faculty of Natural Sciences and Mathematics, Geophysical Institute in Zagreb). The Institute of Process, Power, and Environmental Engineering in Sarajevo is a leader in most air-pollution prevention activities, and its interests extend to modeling (Ivanović, 1990).

Original research on the development and application of numerical atmospheric models with special emphasis on geographic and meteorological conditions specific to Europe has been established by Mesinger at the Institute of Meteorology, University of Belgrade (IMBU). The

IMBU model is a candidate for the EUMAC subproject model of long-range transport, transformation, and deposition of air pollutants on a meso/synoptic scale (Mesinger and Janjić, 1990). This research team cooperates very closely with the Federal Hydrometeorological Institute (HIBU models). This modeling work is also supported by the European Center for Medium-Range Weather Forecasting.

One may conclude that Yugoslavia has very experienced investigators in the atmospheric sciences with meteorological facilities appropriate for research (Vukmirović *et al.*, 1990b). Bringing funds and specialists together in a cooperative Yugoslav program should be a near-term priority.

18.4 Legal Provisions of Environmental Protection

The first federal Yugoslav law on air-pollution prevention was established in 1965. However, after the constitutional amendments of 1972, all legal jurisdiction was transferred to the republics and autonomous provinces.

Practically all republics have accepted the concept of legal provisions based on maximum permitted concentrations (MPC) of major air pollutants established by the former USSR. Slovenia has established a permitted level for SO_2 in 24-hour air samples of 300 micrograms per cubic meter (OB-SR Slovenia, 1976). Serbia is continuing with a value of 150 micrograms per cubic meter in 24-hour air samples (OB-SR Serbia, 1973). Meanwhile, standards for SO_2 have become stricter in the republics of the former USSR and the adoption of new standards in Yugoslavia has been stopped. The lack of legal provisions for control of emissions is the largest cause of air-pollution problems in Yugoslavia. A federal law has been drafted that tries to solve this problem, but its implementation depends on future constitutional changes.

18.5 Effects of Air Pollution on the Biosphere

The influence of polluted air on health has been studied since 1950, but there has been no systematic research. Statistically significant differences are found between urban and rural areas for mortality increase from lung cancer (Belgrade, Pančevo); chronic bronchitis (Zenica, Šabac, Tuzla, Trbovlje, Bor); and sensitivity to virus infections (practically all urban areas). A particularly high degree of contamination from heavy metals is found in T. Mitrovica and Bor.

About one-third of the territory of Yugoslavia is covered by forests. Official analysis of forest damage based on estimates from 1987 shows that every third tree is affected, 58% of these by unknown diseases. The total percentage of damage is 32.2%; including 45.9% for coniferous forests and 27.9% for deciduous forests (FMD-DEP, 1990a). Forest damage coincides with areas 1 and 2 in *Figure 18.2.* Heavy damage in Slovenia and Gorski Kotar (Croatia) also indicates long-range transport of air pollutants.

Durmitor National Park is situated between two coal-fired power plants and receives SO_2 emissions of 30,000 tons per year; Kopaonik National Park (to the north northeast of the Kosovo basin) receives nearly 50,000 tons per year of SO_2 emissions. Forest damage is evident in both national parks.

18.6 Priorities in Air-Pollution Control in Yugoslavia

Areas with air-pollution problems have been categorized in the report entitled *An Overview of Air Pollution Problems in Yugoslavia*, and are described in this section.

18.6.1 Air basin in Obrenovac-Belgrade-Pančevo

Basic Elements

- Population of 2 million (approximately 10% of Yugoslavia's total).
- Emissions of SO_2, NO_x, VOCs, CO, and NH_x (about 20% of national total).
- Complex structure of the lower troposphere including heat island effects.
- Complex topography of urban areas.
- Outmoded public transportation and heavy traffic.
- Mainly noncentralized heating in the old town of Belgrade.

- Climatic characteristics favor occurrence of secondary pollutants in summer.
- Cultural, scientific, administrative, and commercial center of Yugoslavia.

Proposed Control Measures

An Ecological Police (ECOPOL) Center should be organized in Belgrade with three monitor-equipped mobile stations and an automated meteorological station to measure SO_2, NO_x, CO, O_3, and nonmethane hydrocarbons, and to determine particle-size distributions and VOCs. A mass spectrometer coupled with gas chromatograph is needed for detailed analyses. The Center should be connected with the Weather Forecasting Center in the Republic Hydrometeorological Institute in Belgrade.

This investment is necessary to improve control technologies and flue gas purification in Pančevo. Abatement of SO_2 and NO_x emissions and efficient removal of fly ash particles from coal-fired power plants near Obrenovac is recommended for first priority funding by the Federal Ministry for Development.

18.6.2 Steelworks in Zenica (Bosnia and Herzegovina)

Basic Elements

- Zenica Declaration adopted at the First Yugoslav Congress for Air Pollution Prevention, Zenica, 14–16 June 1990.
- Emissions of SO_2 (70,000 tons per year), VOCs, and heavy metals.
- Complex topography.
- Very pronounced effects on health.
- Climatic characteristics favor fog occurrence.

Proposed Control Measures

Complete air-quality management and sanitation including purification of flue gases and improvements of technological processes. Outside assistance needed.

18.6.3 Bor mining and smeltering basin (Serbia)

Basic Elements

- Large-capacity industrial plants of particular importance for Serbia.
- Emissions of SO_2 (150,000 tons per year) and heavy metals.
- Deep valley.
- Climatic characteristics favor air-pollutant transformations.
- Pronounced adverse effects on health.

Proposed Control Measures

Air-pollution monitoring should be modernized and the ECOPOL Center should be connected to the Meteorological Service. Step-by-step abatement of SO_2 emissions is necessary because the concentration in flue gases differs considerably. Measures to be taken include additional processing of copper concentrates; use of better technologies; and recycling of sulfur. Air filtering with preventive maintenance and monthly inspection in preparation of copper ore is recommended.

18.6.4 Lead and zinc refinery in T. Mitrovica (Serbia)

Basic Elements

- Highly toxic due to heavy metals.
- Emissions of SO_2 (30,000 tons per year from stack height of 312 meter) and heavy metals.
- Possible forest damage on the Kopaonik mountain.

Proposed Control Measures

SO_2 emission abatement is necessary and outside assistance would be helpful. Preventive maintenance of existing technical measures is recommended. In addition, strict on-site control must be introduced.

18.6.5 Ljubljana (Slovenia)

Basic Elements

- Cultural, scientific, administrative, commercial, and political center of Slovenia.

- Valley location.
- Climatic characteristics favor heterogeneous processes of air-pollutant transformation, particularly in winter.
- Centralized heating not yet available in parts of the city.
- Heavy traffic.

Proposed Control Measures

Air-quality management should be centralized and completed with advanced monitoring. Flue gas desulfurization equipment should be installed in the thermal power plant of Ljubljana.

18.6.6 Thermal power plants in Trbovlje and Šoštanj (Slovenia)

Basic Elements

- Forest damage and adverse effects on health.
- Emissions of 70,000 tons of SO_2 per year in Trbovlje and 90,000 tons of SO_2 per year in Šoštanj.
- Complex topography.
- Climatic characteristics favor heterogeneous processes of air-pollutant transformation, particularly in winter.

Proposed Control Measures

Flue gas desulfurization equipment to be installed.

18.6.7 Thermal power plants in Kakanj I-V, Tuzla I-V, and Ugljevik I (Bosnia and Herzegovina)

Basic Elements

- Forest damage and effects on health.
- Emissions of 260 tons of SO_2 per year.
- Complex topography.
- Climatic characteristics favor heterogeneous processes of air-pollutant transformation throughout the year.

Proposed Control Measures

Technical and economic analyses of desulfurization processes are being carried out. Assistance of a wider community is most probably needed.

18.6.8 All republic capital cities (Yugoslavia)

Basic Elements

- Cultural, scientific, administrative, and commercial centers of the respective republics; heavily populated areas.
- Synergistic effects of major air pollutants adverse to public health.

Proposed Control Measures

Air-quality management should be centralized and connected with meteorology departments in the cities. Modern air monitoring is needed in all urban areas. The choice of measurement sites should account for the principal goals of air-quality protection using well-known models. Preventive maintenance of devices used in an automated network must be introduced. Relevant departments should be supplied with spare parts and standards for calibration. A system of reference laboratories must be established.

Finally, the use of lead-free gasoline in cars equipped with catalytic converters merits consideration in Yugoslavia.

18.7 Conclusion

Data on ambient air quality and effects on the biosphere have to be evaluated to assess the correct strategy for solving air-pollution problems in Yugoslavia. Priority areas for air-pollution control are heavily populated and industrial areas; areas of special interest to the national economy (cultural, scientific, administrative, and commercial centers); national parks; forested and agricultural areas; and clean water reservoirs and fish ponds.

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Chapter 19

Postscript: Possibilities of a Green Post–Communist Poland

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The transition from an environmentally disruptive economy to an efficient, *green* economy has been the aim of many reform-minded people in Poland. There is no doubt that the environmental unsoundness of the old system has to be abandoned. There is also much faith – often too much – put in the benign environmental implications of the market economy. A lot of confusion, however, arises as to the features of the system to be built. Obviously any regulatory reform will meet resistance by the reformed institutions. This, coupled with the confusion about the

In this postscript the author deals with some key questions of coping with Eastern Europe's environmental crisis: How will environmental protection be financed? How will it be administered? How will it be regulated in the new emerging economies of the region?

right reference point, makes recent Polish environmental developments an interesting aspect in the post–Communist history of East European economies.

This paper is arranged in three sections. In the first section possible benchmarks or standards for modern environmental institutions are discussed briefly. In the following section general directions of Poland's environmental regulatory reform are outlined against this background. The paper concludes with a review of the main actors involved in promoting, directing, or obstructing the reform.

19.1 Finding a Reference Point

As Poland enters the 1990s, it confronts the monumental task of reforming almost every sector of its public life. In the case of economic reform, which is by far the most important one, there is a more or less well-identified minimal set of institutions to be established. These institutions characterize every developed market economy and serve as a reference point for the reformers (that is, the government). As far as other sectors are concerned, the international experience has been much more diversified. It would be difficult to find some nontrivial common institutional denominator in any of the areas of contemporary society including education, culture, medical care, urban policy, or environmental management. The *polluter pays principle* (PPP) and its practical consequences may serve as a good starting point.

The recent OECD report on the use of economic instruments for environmental protection (OECD, 1989) shows that there exist many country-specific variations in applying these instruments. Since 1972 PPP has been officially adopted by the OECD countries as a guideline for carrying out environmental policies. Despite many years of consulting, avoiding, assessing, and actually practicing PPP, it turns out that we have not yet achieved a universal understanding of the principle. It is sufficient here to point to the differences apparent in, say, the German and the Dutch experience. The federal government of Germany interprets PPP philosophically as:

> Those who cause environmental stress and pollution are responsible (in a moral, legal, and economic sense) for the repair of the resulting

> damage and/or for the reduction of environmental stress. This affirmation of PPP is not felt to rule out subsidies, as long as this fundamental responsibility remains. Subsidies are seen as necessary to ensure that industry is able to meet the costs of increasingly strict control. [OECD, 1989, p. 29]

The Dutch government, on the other hand, has interpreted PPP at an even more abstract level by referring to

> the so-called "principle of causation." This principle enables government to regard polluters in general as responsible for pollution, and allows government to levy charges in order to finance environmental management activities decided by public authorities. A direct link between the individual polluter's contribution to particular types of pollution and the costs of management with respect to that type of pollution is not required. [OECD, 1989, p. 29]

Fundamental differences also exist between the Swedish and the US interpretations of the PPP, and so on. With regard to other less widely publicized principles of environmental management, there is even less of a consensus.

In looking for theoretical foundations of environmental policy, one should inevitably consult the classical work of Baumol and Oates (1975, revised 1988). The authors, however, tend to confine the problem of environmental policy (and economics) to dealing with externalities. Correcting for the misallocation of resources caused by externalities emerges as the main purpose of the policy, and acquiring economic efficiency is thus the focal point of the underlying theory.[1] Indeed, no one would dare to disregard efficiency goals. Nevertheless, a number of issues clearly transcend efficiency considerations. It is equally important that ecological, social, and political dimensions of policy measures be addressed too. I have argued elsewhere (Żylicz, 1989, pp. 122–124) that environmental policy should be assessed from the point of view of its "compliance" with the following five principles:

1. Efficiency.
2. Ecologization.
3. Regionalism (subsidiarity).
4. Enforceability.
5. Polluter pays principle.

For the purpose of this discussion, these principles will serve as the substitute for a (nonexisting) comprehensive theory.

The first principle, *efficiency*, is a well-understood notion and no qualifications are necessary. We may just note that, in practice, achieving efficiency in terms of use of a resource (by optimally allocating it among its potential users) requires some sort of a market. It is assumed that both the allocation and the overall quantity used are to be determined by market forces. If there are reasons for believing that the market might fail in setting the right scale of use, a weaker criterion – namely, *cost-effectiveness* – is applied. Here the objective is to achieve an optimal allocation of a fixed amount of the resource in question without letting the market alone determine the quantity.

There is no established understanding of the second principle, *ecologization*. The term is often used to indicate some set of ecological aspirations or requirements. In this paper it is interpreted with regard to Pearce's concept of an ecologically bounded economy (Pearce, 1987). More specifically, as a proxy for the boundedness à la Pearce (which is rather hard to operationalize), Daly's principle of separating scale and allocation decisions will be used (Daly, 1984). This principle was recently echoed in a report on the USA (*Project 88*, 1988, p. vii):

> We are not proposing a free market in the environment – far from it. This ... is not about putting a price on our environment, assigning dollar values to environmental amenities, or auctioning public lands to the highest bidder. What we are proposing is that once tough environmental goals are set, we should design mechanisms for achieving those goals which take advantage of the forces of the marketplace in our economy.

In other words, here ecologization will be understood simply as setting quantity–quality limits regarding the use of environmental resources (for example, in terms of ambient quality standards).

In its sociological sense, the third principle, *regionalism* [2], means much more than mere policy decentralization. For the purpose of this paper, however, the concept will narrowly be interpreted as the division of responsibilities between central and local administrations. It is expected – at least in Poland – that the decision-making level will be kept as local as possible. Any policy is meaningless unless it is enforceable. Hence, our fourth principle, *enforceability*, is perhaps the best-understood principle, even though not a simple one. No further qualifications seem necessary at this point.

In the introduction I briefly referred to a fifth principle – *polluter pays principle* (PPP). In order not to add any new confusion, no Polish interpretation of the principle will be offered. Instead, PPP will be understood simply as an attempt at achieving internalization of external costs.

19.2 New Policy Outline

This section outlines how these principles are being incorporated into the emerging new environmental policy system in Poland. The discussion is based on the policy document which concentrated on the role and scope of economic instruments (National Environmental Policy, 1990).

There are several ways of efficiently regulating environmental protection activities. Pigouvian taxes have been the focal point of environmental economists for many years.[3] It turns out, however, that there are no instances of actual application of this instrument in environmental protection found in any country (OECD, 1989). Effluent charges are typically set below their efficient levels, and direct regulations – rather than an invisible hand – determine the level of emissions. Furthermore, no attempt is now made in Poland to design and implement Pigouvian taxation because of the risk of a market failure, and as a preventive measure against domestic producers facing a competitive disadvantage. The primary function of both the existing and the prospective charges is one of fund-raising. Only recently has this been made explicit, thus stressing the indispensable role of direct regulations which have been used very inconsistently to date.

Property-rights assignment is another theoretical way of achieving efficiency, and, to a degree, Poland has attempted to adopt some simple schemes of this approach. By introducing the concept of emission-reduction credits, the Ministry of Environment is ready to replicate the US experience of the 1970s and 1980s. It is expected that more advanced varieties of marketable permits will follow as soon as environmental authorities are convinced of the usefulness of emissions trading. Any further development will pose the very fundamental question of a firm's rights to emission-reduction credits. Efficiency gains will be considerably lower unless the long-term rules of the game are made clear.

Subsidies can bring about an efficient allocation of abatement effort as well. There are a number of indirect subsidies provided for those who invest in control equipment in Poland. They include tax differentiation, tax allowances, soft loans, and so on. Their coverage has been quite extensive (Paradysz, 1991), but their efficiency has been extremely low which makes them an easy target for financial analysts' criticism. The Ministry tries to defend these instruments by scrutinizing them closely in an effort to develop a policy statement that will ensure more efficient practices. To date, only one institution in Poland – the National Fund for Environmental Protection and Water Resources Management (hereinafter referred to as the National Fund) – offers soft loans for environmental projects. In this case, subsidies accrue from effluent charges and noncompliance fees. Plans exist to give the National Fund a simpler and more manageable base in the form of a fuel charge, and to issue detailed guidelines to financially discipline its expenditures.

Despite some misleading features, Poland's environmental protection in the 1980s was not one of command and control. In principle, firms were required to comply with certain emission limits. A common (and legal) practice, however, was to let them pollute above the set standard for a fine based on a multiple of the effluent charge. Thus, the system resembled a market with unlimited access to the environment, treating it as if its resources were limitless. The Ministry of Environment has attempted to solve this problem by (1) making more courageous use of administrative instruments, including forced shutdowns, and (2) reforming the fine system (noncompliance fees should be assessed in the case of accidental spillovers only; otherwise, there are no clear means by which to limit the use of environmental resources).

Marketable pollution permits perfectly conform with Daly's idea of separating scale and allocation decisions, and their use will be encouraged gradually. Marketable permits are environmentally safe in the sense that the issuing authority controls the overall quantity of allowed pollution, and lets the market determine a cost-effective allocation of abatement effort only. As a result, issues of efficiency and ecologization are addressed simultaneously.

In Poland, regional environmental authorities are responsible for complying with national ambient quality standards. In this sense, their independence will remain constrained. However, simultaneously, they will be given the freedom of choosing any method of policy implementation they consider most appropriate. The Ministry proposes extensive amendments to environmental legislation to create as much leeway for local ecological initiatives as possible. As well, those who are responsible for attaining ambient quality standards will also be given the right to set effluent charges to raise the funds they deem necessary to manage the environment in their region.

In the field of water-resources management, regionalism means establishing basin agencies granted with a wide range of responsibilities. In particular, they will be given the right to charge water users the full cost to make their budgets self-financing within two to three years from now.

The old system of environmental management in Poland was notorious for its poor enforceability. There were at least two reasons which allowed polluters to feel safe. First, in a centrally planned economy, which almost by definition is a shortage economy, firms operate under constant pressure (from state authorities) to produce. In the case of conflicts between protection and production, the former must inevitably yield to the latter. The second reason could be linked to the system of noncompliance fees which excused firms from making a sufficient abatement effort. Both factors (that is, a shortage economy and the inconsistency in applying direct environmental regulations) are fading away, which theoretically should make firms less immune to environmental enforcement. In practice, however, enforceability will remain questionable as long as the administrators lack adequate monitoring capabilities, and the largest polluters are facing serious financial troubles – which invokes the usual employment-versus-environment argument.

Structural changes currently experienced by Poland's economy have led to financial problems in many firms. Some firms have gone bankrupt, often leaving devastated plant sites and contaminated neighborhoods. In the absence of a proper insurance system, it is easy to see why PPP cannot be applied in many cases. Both obligatory insurance and deposit or performance bonds will probably be included in the new system, but it will take time to implement them. Meanwhile, state and local authorities will continue to pay the bills of the past.

The knowledge of environmental experience of modern market economies and the awareness of the dilemmas involved in the choice of policy instruments are growing rapidly in Poland. Still, Polish environmentalists have much to do before a viable and effective system is in place. A *provision for revision* is therefore another important feature that the current reform should, and in fact does, take into account.

19.3 The Transition

A number of actors, both individual and institutional, are active in Poland's environmental area. The configuration is complex and far from a simple dichotomy such as environmentalists versus developers. The weakness of both groups results in a much more diversified pattern.

It would be unwise to completely disregard environmental lobbies. Occasionally they file complaints, organize on-site events, give media interviews, yet these activities do not have any serious effect due to the low social awareness. The most complete summary of Polish environmentalists' views is included in the Protocol of the Round-Table (1989).

Two issues of interest in this context proved lasting despite the political roulette. One is the preference for regional decentralization of environmental authority (starting with water-basin management agencies). The other is the separation of the National Fund from the Ministry of Environment. Since mid-1989 the National Fund, in fact, has been separated and now reports to a board consisting of representatives of several ministries, parliament, and NGOs.[4] As for developers, there are hardly any involved in environmental debates in Poland. In 1990, a number of voivodes (regional administrators) – acting on behalf of suburban coal-fired greenhouse owners – filed complaints about the excessive level of emission charges. Apart from that, industry has stayed rather quiet except for lamenting about its financial predicament.

Despite all its diversity, the Ministry of Environment should be identified as the architect and promoter of the reform. While most of the institutional setup was already designed at the time of the Round-Table talks, efficiency and the rational use of market mechanisms were later additions. Here the Ministry has to confront a myriad of amateur economists from the parliament, NGOs, academia, and various parts of the government, who strongly advocate Pigouvian taxation even though the term is not explicitly referred to. Most of the discussants were sure that market economies rely on price incentives when managing environmental quality. The belief has been so overwhelming that the Ministry decided to publish (and distribute free of charge) a Polish translation of the 1989 OECD report which proves the contrary. Translations of other reports are under way to correct the false image of western environmental policies.

An attempt at experimenting with Pigouvian taxation would be dangerous. For equity reasons it would be clearly impossible to raise emission charges to their efficient levels. In these circumstances, to claim that incentive charging is a prerequisite for environmental protection would be equivalent to admitting that the protection is premature. Indeed, it looks as if some proponents of solving the problem through price mechanisms – at least subconsciously – were expecting such a bottom line.

There is also a common belief in Poland that environmental protection does not require expenditures provided the polluters are given the *right* price incentives. As a result, people resist any idea of bearing the burden of abatement. Meanwhile, the Communists are expected to pay for the cleanup of the mess they created. Nobody is verbally against environmental protection. However, when it comes to money even moderate proposals meet with resistance. In 1990 the Ministry tried to introduce an average 4% (*ad valorem*) fuel charge earmarked for environmental protection. The proposal met with almost unanimous opposition. The official opinion of Solidarity was typical. It stated: "While the Union is for environmental protection, it will not approve any such burden laid on the impoverished society."[5]

The resistance to introducing product charges viewed as a source of revenues for the National Fund is inconsistent with the widespread expectation that 100% of emission charges and noncompliance fees should be retained at the voivodship level. As long as it is also expected that some funding from a central fund has to be available, the only way to reconcile the two propositions – without totally ignoring the PPP by charging the general taxpayer – is to accept the idea of product charges. This new idea, however, is resisted on several grounds. The reluctance to accept an additional burden was already identified, but more sophisticated arguments are available too.

Currently, a group of lawyers is actively working on drafts of several regulations on environmental protection (general acts and sectoral laws on water, forestry, waste, inspection, and so on). The lawyers seem to be delighted by the conceptual vacuum left after the Communists, and by a possibility of building from scratch. As a result they tend to disregard actual world experience, and create concepts appealing to their own sense of beauty and clarity. The idea of a product charge does not fit into this ideal framework, as there should not exist earmarked taxes. Thus it is not quite obvious whether the ministerial bill will make it through.

Also applying an aesthetic argument, the lawyers object to a number of ideas to make state environmental inspection really work at a regional level, despite that such solutions are applied worldwide. These controversies make it difficult to design a rational degree of regionalism, as grievances of municipal governments are strong. Here, in turn, an ideological argument is applied despite obvious world experiences which justify state intervention in municipal authority regarding environmental matters.

In conclusion, the current environmental reform includes most of the relevant opinions of the environmental opposition of the 1980s. As a result, there are no clear alternatives to the proposals of the Ministry of Environment.[6] Nevertheless the reforms progress slowly, as many peripheral issues and loosely involved actors enter the political arena. These can be considered either as manifestations of the social reluctance to pay for environmental protection or as attempts by various professional groups at doing something monumental without questioning the economic efficiency and administrative viability.

Despite all this, in a recent evaluation of East European environmental developments (Dickman, 1990), Poland was identified as the country where institutional reforms have progressed the fastest. The environmentalists in the entire region are now facing a social disappointment since the public has realized that the costs of the cleanup are large, and those guilty of past neglect simply cannot be made financially responsible for the destruction. It will require a massive financial *and* educational effort to render social support for environmental recovery programs, as there is no alternative for the region but to meet the challenge as soon as possible.

In this transition to a greener economy, Poland, as well as the rest of Eastern Europe, has been offered invaluable assistance from the best West European and US experts. Environmental policies for former centrally planned economies have become a part of more general environmental policy studies (Howe, 1991). They have also become a separate target of some analyses (Żylicz, 1990; Dudek *et al.*, 1991). Post–Communist Europe has thus been given a chance to learn from the Western experience and to avoid some of the traps and mistakes. One study of economic instruments concludes with an optimistic statement that is somewhat premature:

> Market-based environmental policies are an ideal tool for nations nurturing new market-based economies. Employing market-based approaches to environmental policy *from the outset* [emphasis added] can avoid some of the costly mistakes made in the US, and propel Eastern Europe into the forefront of environmental protection. [Dudek *et al.*, 1991, p. 31]

The assumption about "the outset" is by far not an obvious one. Although it is true that East European environmental reforms ought to be comprehensive, this does not mean that their architects may start from scratch. The countries of the region have had extensive legislative systems which cannot be ignored without putting at risk environmental objectives (at least in the short run). Also the public's beliefs and convictions should be taken into account when assessing the viability of a given reform scenario, as this paper attempts to illustrate.

Reforming environmental policy institutions in Poland and elsewhere in the region is, perhaps, more difficult than initially expected, but it is also more exciting.

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Notes

[1] This point of view is clearly presented by the *Journal of Environmental Economics and Management*, a leading professional quarterly.
[2] In EC language this is called subsidiarity.
[3] *Pigouvian taxes* are used here to mean taxes high enough to reflect the actual damage caused by pollution.
[4] As before, the National Fund receives roughly 40% of emission charges and noncompliance fees while the rest remains at the voivodship (regional) level.
[5] Now the charge is again on the political agenda, this time at the initiative of a small group of Green members of parliament.
[6] The one possible exception is for Pigouvian taxes.

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