SCIENTIFIC AND EDUCATIONAL PARTNERSHIPS TO ALLEVIATE AQUATIC ENVIRONMENTAL PROBLEMS IN EASTERN EUROPE

**Results of a Workshop
Held at the
Marine Sciences Research Center
April 22, 1992**

marine sciences research center
state university of new york

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"Never doubt that a small group of thoughtful, committed citizens can change the world."
Margaret Mead

"Trouble in the water, trouble in the air, go all the way to the other side of the world and you'll find trouble there."
Bob Dylan

INTRODUCTION

The countries of eastern Europe (in this document "eastern Europe" is taken to include the former Soviet Union) have a number of severe terrestrial and aquatic environmental problems, few of which are unique. Many similar problems have been dealt with, at least partially successfully, in the United States and in other western nations. In particular, aquatic problems associated with eutrophication and pollution caused by toxic chemicals have been identified as being of paramount concern in eastern Europe.

To examine some of these problems, a small invited workshop with a balance of eastern European and American participants was held at the Marine Sciences Research Center, April 5-8, 1992.

The goals of the workshop were:

* to promote a better exchange of scientific knowledge and technology in aquatic sciences among nations of eastern Europe and the United States in order to create a better understanding of the complex relationships between economic development and environmental protection of aquatic and marine systems;

* to identify ways to stimulate cooperative scientific study, understanding, and application of remedial methodologies which may lead to improved management and, in some cases, rehabilitation of heavily impacted aquatic ecosystems.

One of the guiding philosophies behind this conference was the conviction that efforts to alleviate and eliminate toxic contamination and eutrophication problems in eastern Europe would be expedited by drawing on the experience gained in other areas. The processes governing the fate and effects of toxic contaminants and of elevated nutrients in freshwater and marine environments operate independently of national borders. Moreover, many water bodies in eastern Europe and North America are sufficiently similar that exchange of knowledge and information was expected to be especially useful. In some cases, remediation in North America has been successful; in others, scientists are optimistic about better current understanding of problems and are hopeful for remediation in the near future. A workshop on problems of eutrophication and toxic contamination with personal interactions, dialogues, and exchanges of information was considered to be an invaluable step in developing partnerships between scientists on the two continents that would lead to new programs and new management strategies to address these problems. This report summarizes the workshop proceedings.

Nine leading European authorities were invited to participate, representing a spectrum of interests and experience in the problems of toxic pollution and eutrophication. All are active scientists with a broad overview of the aquatic problems in their countries. These scientists and their home countries were

P. Iliev (Bulgaria)
M. Branica (Croatia)
J. Svoma (Czechoslovakia)
A. Aitsam (Estonia)
L. Brugmann ([East]Germany)
P. Literathy (Hungary)
A. Vadineanu (Romania)
K. Korotenko (Russia)
S. Fowler (United Nations International Atomic Energy Agency in Monaco)

All attended. In addition, Dr. D. Schindler of the University of Alberta, Canada, an expert on eutrophication and acid rain in lakes, was present during the meeting (he was at the MSRC as Lawrence Distinguished Visitor for the week). The participant list is appended. Seven students of the Central European University in Budapest, Hungary, all presently studying in the United States, were in attendance. They were invited in recognition of the need of educating and training young scientists from eastern Europe. They represented:

Bulgaria (M. Andreeva)
Czechoslovakia (L. Nemcova)
Hungary (A. Kovacs)
Lithuania (E. Endziulaitis)
Poland (J. Bakiera, P. Rowinski)
Romania (Z. Gyenge)
Russia (G. Ishkuzina)

The conference began with a series of short presentations by participating scientists on the most serious problems in their countries. This was followed by the formation of two working groups, Toxic Contamination (chair N. Fisher) and Eutrophication (chair L. Swanson), which deliberated for two days and identified key areas for action. Their reports are presented in the sections that follow.

The meeting concluded with a plenary session where the two groups presented their key findings.

Executive Summary

Problems common to scientists in virtually all eastern European countries include lack of access to scientific information from other countries (and sometimes their own country), and the need to establish the capability, through training and facility development, of pursuing state-of-the-art environmental measurements in their own waters. Collaboration with scientists from the United States on scientific projects of mutual interest was considered an appropriate step at this time to expedite information and technology exchange and to promote a fuller appreciation of the environmental and management problems and solutions which exist. Emphasis was placed on developing American-European collaborative projects for specific problems, in which priority scientific needs would be met. Most collaborative projects were designed to employ "transportable" techniques and protocols currently in wide use in the U.S. Attempts were made to design projects which would generate useful information in relatively short time periods (typically 2-4 years).

Specific projects suggested for assessment of toxic contamination in eastern Europe include:

(1) analysis of bivalves and sediment in coastal areas of the coastal Black Sea and rivers (especially Danube and Dnieper) flowing into the Black Sea, focusing on the priority contaminants currently investigated by the US National Status and Trends Program;

(2) analysis of bivalves and sediment in coastal areas of the eastern Baltic Sea and rivers flowing into the eastern Baltic, using the same protocol as for the Black Sea;

(3) analysis of atmospherically delivered contamination into coastal areas for select contaminants to compare with riverine input;

(4) special attention to the Kiev reservoir and the Dnieper River system for quantitative assessment of Chernobyl-derived fallout products (especially ^{137}Cs) in drinking water, sediments and fish;

(5) measurement of groundwater contamination in diverse regions of eastern Europe, with application of groundwater flow models and advanced remediation technologies currently in use in the U.S.;

(6) assessment of the impact of toxic contaminants already well documented in western regions of the coastal Baltic, by examining long-term data sets on species assemblages and by using mesocosms for experimental manipulations;

(7) establishment of a solid database on biological and chemical measurements in the eastern Adriatic to serve as a baseline reference for pristine waters not yet heavily impacted by human activities.

Specific projects suggested for assessment of eutrophication in eastern Europe include:

(1) development of techniques for, and estimate values of, aquatic resources in terms of environmental, social and economic benefits, particularly in the eastern Baltic and the Black Sea;

(2) develop mechanisms by which to evaluate and differentiate between natural processes and anthropogenic nutrient-induced problems in the eastern Baltic and coastal areas of the Black Sea;

(3) develop mechanisms to determine non-point source nutrient loads to the eastern Baltic and Black Sea. In particular, develop understanding of the role of fertilizers;

(4) develop mechanisms and determine the assimilative capacity of the eastern Baltic and coastal Black Sea for nutrients;

(5) develop remediation programs that can alleviate the impact of eutrophication with a particular emphasis on the problems associated with fertilizers.

Report of the Toxic Substances Working Group

Given the concern expressed over the extremely high concentrations of toxic substances reported in surface and ground waters of eastern Europe and in coastal regions of the Black Sea and the Baltic Sea, this Working Group considered the research needs of these regions. The Working Group identified several issues which were of general concern for all (or nearly all) regions of eastern Europe. These were:

(a) the development of more reliable data bases for chemical contamination;

(b) the development of analytical capabilities in eastern Europe, including analytical supplies and equipment, training, and in some countries computing resources;

(c) improvement of information exchange and access to information for hands-on scientists, including some non-technical material (e.g., GIS);

(d) establishment of international standards of water quality criteria, with special attention to drinking water and contaminant levels in biota;

(e) development of predictive models to describe biogeochemical cycling and effects of contaminants, including routes to man;

(f) establishing a more reliable data base on the biota of impacted and pristine aquatic ecosystems.

The Working Group attempted to identify priorities for specific collaborative research programs which would:

(1) provide a reliable data base on toxic chemical contamination of water, sediment and biota in aquatic/marine ecosystems of eastern Europe, focusing on those regions where no quality data are currently available and emphasizing existing technologies currently widespread in the US and western Europe;

(2) help assess the impacts of pollution on aquatic/marine ecosystems in select waters (where a reliable data base already exists to demonstrate high concentrations of toxic chemicals);

(3) help establish professional ties between scientists and institutions of eastern Europe and the United States;

(4) help strengthen, through training programs and facility upgrades, the capability of eastern European scientists to

make the necessary measurements that would help them assess the extent and impacts of chemical contamination in their waters.

The Working Group considered heavily-contaminated coastal areas, including sections of the Baltic Sea and the Black Sea, the rivers in the catchment areas of these seas (especially the Danube and Dnieper rivers flowing into the Black Sea and the Polish and Russian rivers flowing into the eastern Baltic), and impacted groundwater throughout regions of eastern Europe. The Working Group also considered the special cases of the Kiev reservoir and Pripyat and Dnieper rivers in the Ukraine, which received massive radioactive fallout from the Chernobyl disaster in 1986, and the case of the eastern Adriatic Sea which could serve as an excellent baseline for pristine coastal waters which are far less impacted by anthropogenic disturbances.

It was considered that the recommended collaborative research projects would help meet the needs expressed by the Working Group members. The recommended projects would use methods well established and in current practice in the U.S., and would mostly be projects for which significant advances could be made in periods of less than 5 years. In many cases, 2 years would probably be sufficient to accomplish the goals of the project. For all recommended projects, one or more scientists from SUNY Stony Brook were identified as having expertise, active involvement in comparable work in the U.S., and interest in collaborating with eastern European scientists.

The Black Sea

The problem: There is growing scientific evidence to suggest that the Black Sea and Azov Sea have been severely impacted as a result of pollution from land-based sources. Two of Europe's largest rivers, the Danube and Dnieper, drain a catchment area which includes an enormous number of industrial, mining and agricultural activities that release a wide variety of toxic substances to the surrounding environment. The uniqueness and delicate nature of the Black Sea, of which 90% of its volume is permanently anoxic, makes it particularly vulnerable to any pollution insult. However, despite strong evidence indicating relatively high inputs of heavy metals, trace organic contaminants, radionuclides and oil, very few reliable data are available on existing concentrations of these contaminants in coastal and offshore waters, or how the levels are changing over time. Such information is urgently needed if the actual causes of the observed ecological effects are going to the discerned.

One reason for the overall lack of reliable and comparable concentration data is that many of the riparian countries are unable to make state-of-the-art trace contaminant measurements. Therefore, as a first step, a considerable amount of measurement capacity building needs to be undertaken in the region.

Recommended action: Recognized lead laboratories in the field of pollutant measurements should be identified in the region that have the potential to carry out such work. Intensive training, both at the lead laboratory and the country laboratory should be initiated and a carefully controlled quality assurance program established in the national laboratory. Simultaneously, a limited pollutant survey program should begin at selected sites in coastal waters. The recommended approach is a "mussel watch" type survey using bivalves and sediments collected from sites both inside and outside areas of obvious contamination. The responsibility for the contaminant measurements will rest with the lead laboratories, however aliquots of the samples will be analyzed by the national laboratories as an integral part of the training and capacity building phase. An international intercalibration exercise component will ensure intercomparability of results between all the laboratories in the region that participate in the Black Sea "mussel watch" survey. The advantage of the "mussel watch" approach is that results from the Black Sea survey will be comparable with similar projects that have taken place or are ongoing in other regional seas. Sampling and analytical techniques and the specific pollutants to be examined should conform with those of NOAA's National Status and Trends Program (in the U.S.).

The Danube

The problem: The Danube river system, one of the largest international river basins in Europe, is shared by eight riparian countries--Germany, Austria, Czechoslovakia, Hungary, Yugoslavia (and former republics of Yugoslavia), Romania, Bulgaria and Moldavia. It provides domestic and industrial water supplies and at the same time it the recipient of domestic and industrial wastewater discharges. Therefore, international cooperation is of vital importance to satisfy the demands placed on the Danube by these countries. Several cooperative agreements have been made or are under consideration concerning pollution monitoring and control along the Danube. One important issue is the establishment of the INFODANUBE program which is under development and sponsored by U.S. aid. There is still a need for a more reliable data base on the extent of contamination in large sections of the Danube, most particularly in the downstream regions nearer the Black Sea.

Recommended action: The following collaborative studies might be initiated regarding the pollution of the Danube. It is recommended that initial emphasis be placed on the first project, listed (1), which can be completed in about 2 years.

(1) Monitoring inorganic and organic pollutants in sediment and selected aquatic organisms such as mussels, macroalgae and/or grasses, and perhaps fish, following the same protocol as for the coastal Black Sea.

(2) Establishment of an inventory of land-based pollutant sources discharging toxic pollutants and nutrients, as well as non-point sources.

(3) Study of transport, sedimentation and resuspension of sediment-associated pollutants (e.g., metals, HOCs, etc.).

(4) Study of the relationship between river pollution and quality of the bankfiltered water used for water supplies (e.g., Budapest Water Works).

(5) Case studies on the effect of the existing dams on the quality of the water in the reservoirs and downstream of the dams, as well as prediction of the effect of planned dam systems, such as the Gabcikovo-Bos-Nagymaros dam system in Czechoslovakia and Hungary, on the water quality of the Danube and related groundwater.

(6) Study of the fate and effects of selected pollutants, characteristic of the Danube, and their pathways entering the Black Sea.

The Dnieper River System

<u>The problem</u>: Key to the pollution problems of the Black Sea are its major tributaries such as the Danube and Dnieper rivers. While the Danube flow rate into the Black Sea is four-fold greater than that of the Pripyat (a tributary of the Dnieper), the concentration of contaminants in waters of the latter may be much higher than the Danube. For example, the Dnieper, which drains the area of high Chernobyl-derived radioactivity contributes six times more ^{90}Sr to the Black Sea than does the Danube. Much of the ^{137}Cs that contaminated the immediate area around Chernobyl is tied up in soils and sediments which will eventually enter the river waters and subsequently the aquatic food chain. ^{137}Cs contaminated sediments are presently accumulating in the Kiev reservoir, which acts as a natural sediment trap. The reservoir serves as the drinking water supply for Kiev and the sediments may act as a source term for ^{137}Cs in the water. At present, there is little information on the rates at which these processes proceed, and

recent recommendations from the International Chernobyl Project underscore the importance of undertaking scientific studies on radionuclide transfer through the aquatic food chain and examining the desorption of ^{90}Sr from reservoir and river sediments.

Besides the special situation concerning Chernobyl-derived long-lived radionuclides, the Dnieper also passes through heavily industrialized and mining areas around Dnepropetrovsk and Zaporozke, where additional contaminant inputs occur. Some of the iron mining activities entail discharges which are enriched in toxic heavy metals and natural series radionuclides. Furthermore, these effluents are highly saline, causing additional insult to the river system. Reliable data on the levels of these materials in the Dnieper and entering the Black Sea are generally lacking and effort should be made to assess the existing data base and verify the quality of the information.

Recommended action: Because of the varied nature of the pollutants entering the Black Sea from the Dnieper, it is extremely important to document the contaminant loads in this river. Monitoring both bivalves and sediment from the Dnieper will allow comparisons to be made with contaminant levels in the Danube. The same monitoring scheme and protocol followed in the coastal Black Sea and the Danube should be followed in the Dnieper system.

The Eastern Baltic

The problem: A substantial input of toxic contaminants enters the eastern Baltic from the five countries bordering this area (Russia, Estonia, Latvia, Lithuania, and Poland). The Neva River drains large areas of Russia, which has a greater flow rate than any other river into the Baltic Sea. Together with the waste waters from the St. Petersburg area, this is the most important point source of contaminants for the Gulf of Finland. The Gulf of Riga is a semi-enclosed area with highly contaminated mud sediments, impacted by the runoff from the Riga and nearby rivers (mainly the Daugava and its tributaries) as well as from Estonia. Nearly all of Poland is drained by two other large rivers flowing into the Baltic, the Odra and the Wisla, which carry a very high contaminant load into Gdansk Bay. Problems there include heavy loading of contaminants from Warsaw and surrounding areas, often due to inadequate waste water treatment and major industrial centers upstream. The Odra Haff/Odra Bight is also believed to receive high levels of contamination from riverine input, possibly including mercury from Poland, although the data base is inadequate.

Unfortunately, for most of the eastern Baltic (including the eastern boddens and haffs of "East" Germany), there is essentially no reliable data base for the "conventional" organic contaminants (DDTs, PCBs, PCTs, HCHs, HCB, PCP, PAHs, PHs...), the "new" organic contaminants (haloforms, PBBs, PBDEs, PCDDs, PCDFs, PCCs, PCNs...), and inorganic contaminants (metals, metalloids, and organo-metallic compounds like TBT and organic mercury compounds). This includes lack of data on water, sediment and biota concentrations. To get reliable mass balances for the Baltic (essential for accurate assessments of remediation measures and implementation of appropriate managements strategies), the fluxes and exchange processes at the interfaces for the land, sediments, and atmosphere must be quantitatively assessed. Moreover, dumpsite of military bases on land in the sea may impact coastal regions of the Baltic, and there is a need to assess the risks associated with these dumpsites. These include camps of the former Soviet Army (illegal deposits of hazardous materials, leaking tanks, etc.) and the dumping of chemical weapons after the two World Wars and in subsequent years (in the Arkona Sea and Bornholm Sea: estimates of 20,000 - 200,000 tonnes of ammunition and other chemicals).

Recommended action: A variety of studies should be conducted, with initial emphasis placed on the first project, listed (1):

(1) A baseline survey of selected inorganic and organic contaminants in sediments and marine bivalves of coastal areas between the German boddens and the St. Petersburg area needs to be conducted. Two years would be sufficient to generate a data base which would enable an assessment of the regional "hot" spots and identification of particular pollutants of concern. This would use the same monitoring and sampling protocol as for the Black Sea and its catchment area;

(2) Analysis of contaminant exchange between water and sediments should be conducted in the Odra Hoff (with scientists from Poland and East Germany), in the Gulf of Riga (scientists from Estonia and Latvia), and in the inner part of the Neva Bight behind the St. Petersburg dam (scientists from Russia and Finland)(3-5 years);

(3) The behavior of contaminants at the interface of rivers with the Baltic should be determined, for study of influx, biogeochemical cycling, organic pollutant degradation, coprecipitation of contaminants, remobilization of contaminants, bed-load transport, etc. These would be measured in the Odra Bight (E. Germany, Poland), Gdansk Bay (Poland, Russia), Gulf of Riga (Estonia, Latvia) and St. Petersburg Bight/Neva mouth area (Russia, Finland)(3-5 years);

(4) A program for the detection and quantification of changes in contamination of the coastal environment due to changes in the economy and technologies of the adjacent countries should be initiated (5-10 years).

Toxicity Studies in the Baltic

The problem: Severe contamination of aquatic ecosystems can disrupt biological communities in these waters. Typically, when contaminant concentrations reach toxic levels, the most commonly observed responses are that sensitive species are replaced by more resistant species. As a consequence, shifts in the species composition of at least one trophic level can result, although the total biomass and productivity commonly remains constant. Because many animals are selective in their ingestion and digestion, ripple effects throughout the food web can result from toxicant impacts on a given trophic level (effects can be from bottom up or from top down).

Once it is established that a body of water is appreciably contaminated with toxic chemicals, it is appropriate to assess the impact of these chemicals on biological communities. Since there is already a well established data base documenting contamination of many sections of the Baltic (particularly the western Baltic), it is appropriate to take the next step in determining whether any biological effects from this contamination have resulted in the Baltic region. Once a more quantitative picture emerges from toxic substance monitoring in the in the Black Sea and its catchment area, including some of the major rivers feeding the Black Sea (e.g., the Danube and Dnieper Rivers), biological impacts of these loadings can and should be examined there as well.

Elevated concentrations of contaminants in the Baltic Sea and the Baltic catchment area have given rise to concern about contaminant concentration in aquatic life, partly from the standpoint as a potential route to man via consumption (direct or indirect) of contaminated seafood, and from the standpoint of ecosystem impacts in contaminated waters. While the contaminant concentrations in commercially harvested species will provide a direct and incontrovertible measure of the extent of seafood transfer to man of toxic chemicals, the influence of toxic substances on aquatic populations is less easy to discern. As with virtually all contaminated waters, any changes in the biological community structure of contaminated Baltic waters are difficult to attribute to the presence of toxicants in the food web, since a multitude of other environmental factors can rarely be ruled out as the causative agent(s).

Recommended action: It is important to examine the extent to which biological communities have changed over time in the Baltic, and this may be possible given the availability of a reliable, very long-term (60 year) data base on coastal community structure. It is therefore recommended that a survey of marine communities be established in the most impacted areas and compared to earlier historical records. Absence of profound changes would argue that toxicant levels are probably below levels which are impacting marine organisms (although other explanations are, of course, possible). Changes in the community structure could be due to the presence of toxic substances, but this would need to be further studied, perhaps experimentally using mesocosm experimentation. Mesocosms have been employed for assessing toxicant impacts in Narragansett and Chesapeake Bays in the US and in coastal North Sea communities (Kiel). Use of mesocosms enables the controlled experimentation of toxicant cycling and impacts on marine coastal communities under conditions which come closer to approximating natural systems than in small, less complicated laboratory cultures. Effects could be very site-specific in the variable brackish water environment of the eastern coastal Baltic, and existing data from other areas should not be extrapolated to the coastal Baltic.

The Adriatic Sea

The problem: The Adriatic Sea has an area of ca. 137000 km^2 and a volume of ca. 35000 km^3. The average depth of this semi-enclosed basin of the Mediterranean is around 250 m. Oceanographic data indicate that the flushing time of the Adriatic is ca. 5 years, with discrete areas ranging from 2 weeks to several months, depending on the volume of water masses, season, currents and prevailing winds.

The western part of the northern Adriatic shows considerable evidence of toxic chemical pollution (Hg, Pb, Cd, Cu, oil, chlorinated hydrocarbons) and eutrophication, caused primarily by the discharge of northern Italian rivers (Po and others) draining industrial and agricultural regions. Similar, but less pronounced effects are observed in the coastal areas of Slovenia and Croatia (in Rijeka and Kastela Bays) and in the vicinity of other harbors and sewage discharge locations. Generally, the Adriatic can be characterized as being a comparatively clean body of water, particularly along the eastern (Croatian) coastline, with exceptions involving certain harbors, bay areas and some sections of the norther Adriatic. The existing data base is important, since it serves as a baseline against which to measure any subsequent pollution.

Recommended action: Joint U.S.-Croatian research on the governing mechanisms, fluxes of critical materials, energy and ecotoxicants is of prime interest in this regard for this pristine region, to better establish the eastern Adriatic as a reference unpolluted marine region. An extensive development of urban and industrial sites on the coastline will inevitably cause a degradation of many existing pristine natural environments within the Adriatic region, particularly if measures for protection and conservation of its aquatic resources are not implemented in the near future. A joint research program, focusing on monitoring of the open and coastal zones of the Adriatic would provide a basis for a very promising "post-industrial" development of one of the most beautiful marine environments in Europe.

Atmospheric Deposition of Toxicants to Coastal Areas

The problem: The atmosphere is an important transport pathway for a wide variety of contaminants including lead and other metals, arsenic, selenium, and many organic compounds (e.g., PAHs, chlorinated hydrocarbons). Deposition of these contaminants may be locally high near the source, and may be regionally important as a non-point source of toxicants to both the terrestrial and marine environments. Effective management of contaminant sources requires knowledge of the magnitude of atmospheric deposition relative to other sources. In the coastal environment, for example, these may include riverine input and wastewater discharges.

Recommended action: Two approaches should be taken to evaluate atmospheric deposition of contaminants. Present day fluxes may be measured by a network of atmospheric deposition sites. Collection of samples should separate wet and dry deposition. Depending on the specific contaminants to be determined, multiple collectors may be required. Collectors can be automated, but samples should be retrieved and stored properly or analyzed at intervals determined by the precipitation and suite of contaminants to be analyzed. Due to the seasonal variability in weather patterns, a minimum of one year is required for effective comparison among sites, and multiple year comparisons are necessary to place the fluxes in the context of year-to-year variations in precipitation.

Direct collection of atmospheric deposition provides a view of contemporary fluxes of contaminants and eventually will be useful to predict trends. The historical perspective is gained from deposits which receive contaminant inputs principally by atmospheric deposition. These include high salt marshes in coastal areas and ambrotrophic peat bogs elsewhere. Such deposits may be dated using natural radionuclides (e.g., ^{210}Pb, supplied by the atmosphere) and the ^{210}Pb chronology forms the basis for chronologies of contaminant fluxes over the past 100 years. A clear requirement of this approach is that the contaminants of interest must be immobile in the sediments and the validity of this assumption will vary with the contaminant.

Both of the approaches described here are potentially fruitful areas of research collaboration between US and eastern European scientists. Contaminants which should be part of such work include Pb (and organic Pb), Cu, Zn, Hg, As, Se, PAHs, and PCBs.

Groundwater Pollution Problems

The problem: In large areas of several eastern European nations (e.g., Czechoslovakia, Croatia, Hungary, Poland), groundwater is the dominant source of drinking water. Aquifer contamination in these regions have been reported with a variety of toxic organic chemicals (e.g., PCBs, chlorinated organic solvents, petroleum hydrocarbons, diesel oils, kerosene, dieldrin, lindane, aldrin) and metals and metalloids (mercury and organomercurials, lead, arsenic, cadmium, zinc, copper). Many of the organic contaminants (especially oils) derive from leakage from underground storage tanks and pipelines, especially near airports, military bases (current and former) and oil refineries. PCBs derive from industrial uses, primarily involving electrical transformers and capacitors. Chlorinated solvents derive from dry cleaning facilities, electronics factories, and other assorted industrial applications. Metals derive from waste disposal sites, industrial and mine effluents, or from soil matrices after leaching by acid rain.

Recommended action: There are three areas which merit collaboration between east European and US-based scientists:

(1) development of regional groundwater flow models;

(2) monitoring of non-point source contaminant influx into groundwater;

(3) implementation of new bioremediation and other advance technologies to remediate contamination of particular aquifers.

Flow models: The development of regional groundwater flow models is important for two reasons. Most importantly, regional flow models serve as a hydrological framework for detailed, small scale flow and transport models to evaluate the dispersion of contaminants from specific point sources. For example, on Long Island (New York), it is common practice to use the regional groundwater flow model as boundary conditions for small scale contaminant transport models. Secondly, regional flow models are necessary to properly manage and protect groundwater resources. Regional flow models are important tools in identifying critical recharge areas which should receive environmental protection and in predicting the effect of water withdrawals on the regional hydrology.

To develop regional groundwater flow models it will be necessary to first review existing hydrological data and then conceptualize a hydrological model. Finally, the conceptual model must be translated into a numerical model. Most of the basic hydrological and geological data necessary to build regional models is available but needs to be collected and evaluated. It is particularly in the conceptualization and design of the numerical model where the east Europeans will benefit from a close collaboration with US scientists.

To carry out this proposed collaborative research, it will be necessary to upgrade local computing systems, instruct local hydrologists in the use of computer models, and maintain computer facilities. It is critical that a good working relation is established between modelers and model users. Model users can provide new data that can be used to upgrade the regional model. Access and development of remote sensing techniques for multispectral and multitemporal analyses to detect and identify pollutant sources on a regional scale would be helpful in building regional flow models.

Based on the fact that most regional watersheds are part of more than one country (e.g., the Danube), it will take approximately two years to collect and evaluate the basic hydrological data. In the third year, a numerical model may be completed.

Non-point source contaminant influx: See section on Atmospheric deposition of toxicants, above.

Implementation of new remediation techniques: Bioremediation techniques are promising alternatives to the widely applied pump and treat techniques for the remediation of some contaminated aquifers. However, most of these techniques are still in the developmental stages. A close collaboration between US and east European scientists in a number of in situ test programs may demonstrate the usefulness of bioremediation for a several types of pollutants, including petroleum products, metals, and perhaps pesticides. Other advanced techniques that should be implemented are ozonization and UV irradiation. These techniques are available in the US but are not applied in eastern Europe. These advanced techniques would be especially useful in cleaning up PCB-containing waters. With a combined rinse and treat system, soils can also be cleaned with these techniques.

Report of the Eutrophication Working Group

Eutrophic and potentially hypoxic or anoxic conditions in riverine, estuarine and coastal systems are now recognized as global and potentially growing problems. Many aquatic systems that exhibit eutrophication/hypoxia are considered to be impacted by anthropogenic nutrient inputs. Such inputs come in many forms, including point and non-point sources. Sewage, agricultural and urban runoff, and atmospheric deposition all contribute to the problem to various degrees.

Considering the global nature of eutrophication/hypoxia and the fact that there are regional differences in approaches taken to understand, control and remediate these conditions, there is much that might be gained through collaboration between eastern European countries and the U.S. Collaborative research endeavors should strive for better understanding of nutrient processes, improvement and expansion of data bases, and implementation of better and expanded management programs.

To this end, the objective of this section is **to develop the basis of a proposal to be presented to the United Nations on a collaborative effort between countries of eastern Europe and the United States to help understand and resolve hypoxic/eutrophication problems.**

We have identified a number of important issues under the general heading of nutrient inputs, nutrient effects and management issues. We have also identified a number of potential collaborative projects, through which both east and west can benefit.

The Black Sea

The Problem:

Even though 90% of the volume of the Black Sea is permanently hypoxic or anoxic there is growing concern that even the oxygenated surface layer of 100 m or so is now threatened by anthropogenic inputs of nutrients. This problem may have occurred over the last three decades of intense industrialization, although leakage of hypoxic waters from depth to the surface may occur as well. There is recent evidence, for example, that there has been an increase in algal blooms along the Romanian coast in association with the Danube drainage basin. Blooms such as these may be directly related to the anthropogenic input of nitrogen and phosphorus which are being added to the system in a ratio of roughly 4:1.

Apparently large anthropogenic inputs of nutrients and other chemicals cannot be assimilated readily by the Black Sea system even though this is the largest inland body of water in the world. This is because there is limited exchange of water through the Bosporus to the Mediterranean and also because there is strong summer stratification in the upper 25 m of the water column. Vertical mixing is generally limited to the upper 75 - 100 m. Fresh water withdrawal from rivers emptying into the Black Sea may have also further reduced exchange of Black Sea waters with the Mediterranean, thereby gradually reducing the salinity contrast between surface and bottom waters. A reduction of this type may have a pronounced effect on exchange of nutrients and organic carbon throughout the water column.

Recommended Action:
Understanding the Black Sea with its complex limited circulation and large anthropogenic nutrient loadings would be particularly well served through application of water quality models. Since many of the manifestations of eutrophication in near surface waters are recent (last 30 years) and water column gradients are relatively large (but perhaps changing), this body of water would be particularly well suited to modeling techniques.

Attention should focus on identifying the nutrient limiting primary production in specific regions of the Black Sea and measuring its concentration seasonally. The impact of basin geography and fresh water input on water column circulation should also be addressed.

Specific objectives should include:

1. Identification of the role of fresh water withdrawal on the circulation in the Black Sea. Would a reversal of current practices alter the likelihood of eutrophication in near surface waters?

2. What effect would increased sewage treatment have in specific regions of the Black Sea? What level of sewage treatment is necessary to achieve the greatest benefit with regard to eutrophication?

3. Can control of non-point sources of nutrients significantly reduce the likelihood of eutrophication? Partitioning of these non-point sources would be necessary. Atmospheric inputs, fertilizers, and untreated agricultural and domestic waste may all be important nutrient loads to the Black Sea system.

4. The economic benefits to the fishing industry, tourism, and overall environmental health should be undertaken.

The Baltic Sea

The Problem: Mass mortalities, particularly of benthic fauna, have occurred in the deeper basins of the Baltic, where anaerobic conditions may persist for as long as four years. Total absence of dissolved oxygen, beginning in 1957, caused the deeper parts of the Gotland, Gdansk, and Bornholm basins to become lifeless deserts in 1958-59. The total area affected was estimated at 41,200 km^2. The stagnation was broken in 1962 by a strong inflow of saline water from the Kattegat. Significantly, great amounts of nutrients accumulated during the stagnation period. These were brought to the surface in 1962, resulting in an enormous increase in plankton biomass. A similar event occurred in the early 1930's. This periodic stagnation, broken by saline inflows and followed by uplift of nutrients, favors periodic increase in biological production.

There are programs ongoing in the Baltic that are examining the physical processes that contribute to the hypoxic problem. However, there appears to be little understanding of the interaction of the small basins of the Eastern and Southern Baltic with the wider Baltic, for example in the area of the Lubeck and Mechlenburg Bights, and the Gulfs of Finland and Riga. In the Bights of eastern Germany there have not only been observations of depressed dissolved oxygen, but the absence of some molluscan species.

Generally, accurate quantification of nutrient inputs to these coastal systems is lacking, and in particular, mass loading from atmospheric deposition, agricultural runoff (including animal wastes and fertilizers) and inadequate sewage treatment.

Recommended Action: In general, there is a requirement to develop circulation models linking the small coastal basins with the larger Baltic basin. Water quality models should also be developed for the same geographic regions. However, considerable effort is needed to quantify mass loads of nutrient to those coastal systems including atmospheric loadings, waste from animal husbandry operations, fertilizers (both from production and application) and municipal wastes.

An agreement has been reached by the Baltic states to reduce emissions of nutrients and other contaminants by 50%. To understand the importance of these waste load allocations, it is necessary to understand the consequences of existing loading and their impact on the marine ecosystems.

The Adriatic Sea

The Problem: The Adriatic Sea has a surface area of 130,000 Km^2, 1/6 of the total Mediterranean surface area. It has been an important resource for the countries surrounding it. Every year it attracts 25 million tourists and it counts more than 35,000 industries on its coast. Commercial fisheries are also well developed in this area, contributing 150,000 tonnes/yr of fish, 20% of the total catch in the Mediterranean. The northern part of the Adriatic is the most eutrophied region of the Mediterranean, probably due to significant nutrient loadings through freshwater runoff and its particular hydrogeological characteristics.

The northern Adriatic is relatively shallow compared to the rest of the Adriatic (mean depth 38 m), and its salinity is fairly low. During winter the prevailing cyclonic water circulation is strengthened by northeastern winds. During summer, however, the general cyclonic circulation is weakened, and southwestern winds may carry water from the Italian to the Istrian coast. Freshwater discharge rate is relatively high on the Italian coast (1900 m^3/sec), where most of the rivers emptying into the Adriatic are located. The amount of fresh water discharged into the Adriatic is 1/6 of the total fresh water emptied into the Mediterranean. The Po River, located on the eastern coast of Italy, is one of the major sources of nutrient loads to the Adriatic. It comes from a drainage basin of about 70,000 Km^2, that is densely populated (16 million inhabitants), hugely industrialized (more than 200,000 factories), and where agriculture is also very well developed (70% of Italy's husbandry sector is located in this area). Summertime thermal stratification and prevailing winds, high river runoff, and the high nutrient influx from the Po result in periodic eutrophication and subsequent hypoxia in this area. For example, in 1989, near anoxic conditions occurred in the bottom layers, with mass mortality of benthic organisms over about 1000 Km^2 area: up to 7,000 tonnes of benthic organisms were washed ashore. Summer transversal winds can bring nutrient rich water from the western Adriatic to the Istrian coast. Local anthropogenically-related eutrophication has been identified along the Croatian coast as well, especially within the harbor areas of the larger urban or industrial centers in the north. These episodes have been related to inadequate wastewater disposal. As a consequence, anthropogenic related phenomena such as near bottom anoxic conditions and gelatinous aggregate problems have been reported.

Eutrophication along the northern Croatian coast, may be due to the transport of eutrophied waters across the Adriatic from the northern Italian Coast as well as to the influence of improperly treated and dispersed sewage effluent from Croatia.

Recommended Action: It is generally believed that local eutrophication problems in the Croatian coastal region can be eliminated by disposing urban and pretreated industrial waste waters in the open coastal sea using submarine outfalls. This may be true, but siting problems (depth and geographic positions) could be effectively analyzed through modeling techniques. If mass loads are transported to the central basin from the Italian coast these additional wastewater loads may exacerbate the present situation. Closed summertime circulation may prevent open communication to the south. Thus, a much better understanding of physical transport and mixing processes in the northern Adriatic would be beneficial. Environmental monitoring should be a first step in evaluating technical solutions to help alleviate the problems encountered in the area. Understanding the source and magnitude of nutrient loads, as well as their effect on the receiving body of water is very important. A Yugoslav national monitoring program was started in 1983 by UNEP. This program should be evaluated and expanded to include a monitoring activity in Italy.

A unified and coordinated program between the governments of Croatia and Italy would be beneficial. Goals should be to assess the anthropogenic influence on the eutrophication of the northern Adriatic, identify specific factors contributing to the problem, identify remedial measures (perhaps a wasteload allocation program), and assess implemented management strategies.

Scientists in the U.S. have had considerable experience in designing and implementing such programs. They could be helpful in assessing the overall issue and in the design and implementation of physical processes studies, modeling and monitoring design.

APPENDIX 1

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The Baltic Sea Environmental Problems
Especially with reference to the Baltic States

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The Baltic Sea is the largest brackish water body in the world. The area of the sea, not including the Danish Sounds, is 366 km^2 and its volume is 21,600 km^3. The maximum depth is 597 m and average depth is 60 m. The Baltic Sea is connected with the North Sea through the Danish Sound.

About 90 million people living in the Baltic Sea drainage area are responsible for about 15% of the world's industrial production, which has increased 5-15 times since World War II.

Signs of the overexploitations of natural resources are obvious: large scale toxic plankton blooms; overfishing of herring, cod and salmon; anoxia over much of the bottom of the Baltic Sea proper; prohibition of bathing at different coasts; and eutrophication of some coastal areas is evident.

The main concern of the Baltic Sea, especially for the Baltic States, is the eutrophication of some coastal areas. Due to the removal of phosphorus in large sewage treatment plants, phosphorus is often the most limiting nutrient of the eutrophication. The limiting nutrient is not the same for different algal species. Unfortunately, case studies of coastal area eutrophication and determination of permissable limiting nutrient loads are scarce for the Baltic States' coastal areas. Nutrient removal from sewage in treatment plants is based on HELCOM recommendations, which are valid for open Baltic Sea and do not take into account local ecosystem peculiarities. It is of the utmost importance to develop the treatment criteria based on local ecosystems conditions.

According to the results of the Second Periodic Assessment of the State of the Marine Environment of the Baltic Sea 1984-1988, the following for the open Baltic Sea could be stated:

- DDT and PCB concentrations in the biota have decreased since 1970.
- Trace element concentrations in fish and shellfish have not changed markedly since the early 1980's. Mercury concentrations in the biota do not differ from those in the North Sea and the Northeast Atlantic.
- The current stagnation period in the Eastern Gotland Basin is regarded as one of the longest and most serious recorded during this century. The area with insufficient oxygen conditions for macrofauna has not increased for 25 years in the Central Baltic

Sea and the Gulf of Finland.
- In many areas, the strong increases of phosphorous and nitrogen concentrations observed in the 1970's have stopped.
- Unusual algal blooms appear to occur more frequently in the Kattegat and the Belt Sea.

The role of the Northern Hemisphere climate change in the observed Baltic Sea environment changes inflow of fresh Atlantic water,and nutrients transport from deep layers to upper layers are unknown.

We also need to improve our basic understanding of algal blooms, including why some of them are toxic, as this will provide a better basis for managing the Baltic Sea in the future. The impacts of changes in climate of the Northern Hemisphere on the Baltic, including inflow of fresh Atlantic water and nutrient dynamics in the Baltic, are unknown and should ultimately be investigated.

AQUATIC ENVIRONMENTAL PROBLEMS IN CROATIA AND YUGOSLAVIA

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The protection of the aquatic environment had an important place in the legislative acts of the former Socialist Federal Republic of Yugoslavia. The fundamental issues of this legislation have also been accepted by the Republic of Croatia and other newly formed independent states.

Numerous regulations for the protection of natural waters are in existence, including rules for the construction and operation of wastewater treatment facilities. Such regulations incorporate the criteria for the required category of water in practically every river or body of water. However, the enforcement of these acts in our country is weak due to wayward inspection forces and sanctioning procedures. As a result, there are many cases where the quality of water is considerably below the ordinance level.

Rivers

The Sava, our longest river, has an average flow of 1750 m^3/s (at its mouth). It is clean only in the first 20-30 km (in the Republic of Slovenia). Due to a variety of effluents--industrial, agricultural and domestic wastes--discharged into it, the river shows severe signs of pollution, particularly at times of low water level. Regulations require that the quality of Sava water never exceed category II (i.e. > 6 mg O_2/L). But in Croatia alone, point sources of pollution contribute an estimated 21 m^3/s of untreated effluents to the Sava, rendering it unsuitable for recreational purposes, fishing, and even some industrial uses which require cleaner water. Particularly critical is the quality of water in the Belgrade area, since one-third of its tap-water comes from the river.

The Drava, the principal watercourse of northern Slovenia and northern Croatia, is extensively used for hydroelectric power (Austria, Slovenia, Croatia), industry (Austria, Slovenia) and agricultural purposes (Croatia, Hungary). The Mura carries considerable amounts of industrial and urban runoff from Austria, and the water quality is of category IV. In the whole of its course through Croatia (borderline with Hungary), the Drava is considerably less polluted than the Sava, due to the fact that its water-level fluctuation is much smaller.

The average flow of the Danube river is 2700 m^3/s, the average width in Croatia being about 800 m. It receives large amounts of industrial and domestic discharge waters from industrial sites and urban centers in Vojvodina (Apatin, Backa Palanka, Novi Sad, Pancevo), Croatia (Vukovar), and Serbia. Recent data show that approximately 330,000 m^3/day of wastewater are released from the territory of Vojvodina, with an average BOD_5 load of 40 tons/day. The estimated autopurification ability of the Danube in this area is equivalent to about 300 BOD_5 tons/day. Consequently, the Danube is not significantly polluted with respect to organic material. The average BOD_5 value for Danube waters (in Croatia) is 3.8 g/m^3. Radiological monitoring of the Danube river since 1958 shows increased radioactivity levels, depending on the season and hydrologic conditions.

Systematic studies of the four major rivers of the Croatian Adriatic coast (the Zrmanja, Krka, Cetina and Neretva) have indicated that the waters of these rivers are inherently clean, mainly due to their karstic drainage basins. However, increased levels of nitrogen and phosphorus compounds have recently been observed in the Krka river (below the cities of Knin and Drnis; untreated urban and farms sewage, as well as industrial runoff), and the Neretva river downstream from Mostar and Opuzen. Recently, parts of the Cetina River have been polluted by intentional oil spillage from the Peruca HE power plant.

Lakes

Numerous lakes show different levels of organic productivity with corresponding rates of eutrophication. This is governed by the natural characteristics of the watershed environment, but also by human activities. Recent research has shown that the quality of water rarely exceeds category II. The present war activities have endangered the barriers and lakes of the Plitvice and Krka National Parks, as well as the accumulation lake of the Peruca HE power plant. A problem of special and international significance is the hydraulic drainage of several lakes in Macedonia (particularly the Dojran and Prespa lakes) during the dry season when large water masses are siphoned off southwards into Greece.

Groundwater

The gravels of the Sava valley form suitable groundwater aquifers which supply a major portion (98%) of the water supply for Zagreb. The increasing quality of water with distance from the Sava river is observed, and a corresponding decrease in well capacity. The pollution effects and changes of Sava water quality will influence the groundwaters. These waters are endangered by the NE power plant Krkos (about 30 km upstream of Zagreb). It operates with a water-through cooling system using 22 m^3/s of riverine water.

In our country, estimates of the quality of natural waters are mostly done in terms of overall parameters such as oxygen demand (BOD and COD), suspended matter load, oxygen concentration, total nitrogen and phosphorus compounds, and number of bacteria. There are considerably fewer data on discrete organic and inorganic compounds which could indicate the respective point sources of pollution.

The general effect of pollution on several watershed areas has resulted in a deterioration in the quality and the possibility of its use as drinking water.

A review of the present state of the aquatic environment shows that many rivers are endangered with organic and inorganic toxic substances from anthropogenic sources. Extensively preserved pristine natural aquatic environments have become rare and can be found only in some lakes, groundwater, at the sources of rivers, in upper flows of Adriatic rivers, and in national park reserves. The general characteristic of the aquatic environment is the steady deterioration of environmental quality, especially in the case of certain rivers where pollution with organic compounds of high molecular weight and a corresponding ecosystem degradation is observed. There is a pronounced and progressive lack of good-quality drinking water in expanding urban and industrial areas.

A system for assessing the influence of polluted waters upon ecological systems and human health has not yet been widely introduced. There is also no detailed monitoring service, water-quality register, or communication system/network. The principal activities in the water management programs are focused on water exploitation and flood-control systems, while monitoring and protection of the quality of water resources has received less attention. It is thus imperative to promptly instigate efficient measures to control further pollution of the aquatic environments, including the construction of requisite wastewater treatment plants. Furthermore, the protection of groundwater has to be fostered in order to achieve a sufficient supply of quality drinking water.

<u>The marine environment</u>

The Adriatic Sea has an area of 135,000 km^2 and a volume of 35,000 km^3. The average depth is around 260 m, and it is a semi-enclosed basin of the Mediterranean sea.

Oceanographic data indicate that the flushing time of the Adriatic is about 5 years. Flushing times of discreet areas range from 2 weeks to several months, depending on the volume of the water masses, season, currents, and prevailing winds.

The western part of the northern Adriatic shows considerable eutrophication effects, caused primarily by the discharge of north Italian rivers (Po and others) and local sewage releases along the Italian Adriatic coastline. Similar, but less pronounced effects are observed in the coastal areas of Slovenia and in the Rijeka and Kastela Bays. Other areas can be regarded as largely eutrophication-free. However, high concentrations of nutrients have been measured in the vicinity of harbors and sewage discharge locations.

Values of measured trace heavy metal concentrations for open Adriatic waters show that these are consistent with respective concentrations in unpolluted seawater. However, concentrations of mercury in tuna and some other marine organisms of the Mediterranean and Adriatic sea indicate that small elevations in seawater concentrations of such elements can increase drastically in higher organisms by accumulation through the trophic chain/web.

Elevated seawater concentrations of some metals were observed in certain open waters of the northern Adriatic and in the vicinity of harbors and larger urban settlements on the eastern coast (Portoroz, Rijeka, Sibenik, Kastela Bay).

Sediment samples from the Adriatic sea show the presence of natural radionuclides, but also artificial nuclides and fission products as well as effluents from the nuclear power industry. Mainly nuclides wtih long decay times have been identified.

The major section of the Adriatic coastal waters do not present a health hazard for swimmers, and the water quality falls well within accepted criteria. However, seasonal variations in the microbiological quality, assessed through the number of bacteria and BOD, indicate certain hot-spots which are influenced by fecal waters, and which could present a recreational health hazard.

Locations used for aquaculture (fish, mussels and other shellfish) should be subject to strict sanitary control, both during growth and subsequent marketing. The present state of affairs is not satisfactory in all cases.

It can be roughly estimated that around 10,000 tons of oil (and its derivates) enter the Adriatic Sea annually. The major part enters via the atmosphere, while the other part is released by point sources of pollution. Phenolic compounds are present both in industrial effluents and in municipal sewage. There is as yet no estimate on the quantity of phenols entering this environment. Hydrocarbon concentrations in surface waters of Trieste bay rise up to 8000 kg/km^2, while values for benzpyrene approach 10 ppm in plankton and 0.8 ppm in fish.

Surface-active substances are present at an average concentration of 0.5 mgeqv/L of T-X-100. The available data mostly correspond to very clean seawater (10 ug NaLS/L), but certain coastal waters have shown 50-fold higher concentrations of detergents (0.5mg

NaLS/L).

The abundance of phytoplankton in certain coastal waters has shown an order of magnitude increase in recent years. This was not always the result of pollution, but was rather an effect of natural variations and fluctuations. Pollution from urban areas has a significant influence on the phytoplankton count during summer months, particularly in surface waters. In place of the stagnation which was observed earlier, an additional summer phytoplankton bloom is now present.

No quantitative assessment of zooplankton can be done for the Adriatic Sea. Differing approaches between various research groups and the lack of intercalibration exercises make a comparison of data unfeasible. In the investigated areas, the coastal benthic communities show no signs of being endangered by pollution.

A general conclusion can be drawn that the Adriatic Sea is still very clean, particularly along the eastern coastline, with exceptions involving certain harbors, bay areas and some sections of the northern Adriatic. The existing database is of importance, since it presents a basis for an estimate of the "background" state of the Adriatic. Research on the governing mechanisms, fluxes of critical materials, energy and ecotoxicants is of prime interest for this region.

An extensive development of urban and industrial sites on the coastline will inevitably cause the degradation of many existing pristine natural environments within the Adriatic region unless measures for the protection and conservation of its aquatic environments are timely implemented.

Extensive and modern research as well as focused monitoring of the Adriatic Sea and coastal zone can be a basis for promising "post-industrial" development of one of the most beautiful marine environments in Europe.

AQUATIC ENVIRONMENTAL PROBLEMS IN (EAST) GERMANY

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Introduction

When the former GDR joined the FRG in 1990, it brought into the unified Germany several huge environmental problems. This is especially true for the quality of the surface waters draining the territories of the five "new (East German) countries"--Mecklenburg-Vorpommern, Brandenburg, Sachsen-Anhalt, Sachsen and Thuringen--into either tributaries of the North Sea (mainly Elbe and Werra/Fulda; about 78% of the territory) or the Baltic Sea (about 22%). Obviously, the main problems are located in the North Sea catchment area. Outdated technologies in the industry there have caused severe contamination of water, soil, and atmosphere. A typical example is the heavy metal load in the Elbe river, which has risen to nearly 90 ug Zn, 28 ug Ni, 13 ug Cu, 3 ug Pb, 0.8 ug Hg and 0.7 ug Cd/L water. One of the main polluters, a chloralkaline plant (300,000 t chlorine/year) in Bitterfeld emitted annually at least 3.5 t Hg alone.

In the present paper, the environmental quality and possible trends of the surface and coastal waters of Mecklenburg-Vorpommern exclusively shall be discussed.

The outer coast of the former GDR has a generalized length of nearly 340 km, or about 1.7% of the total coastal length of the Baltic Sea. Most of the coastal area is unique to the Baltic Sea because it represents also a complex system of inner water bodies, so-called "boddens" and "haffs", which altogether enlarge the coastline to about 1470 km. These boddens and haffs cover an area of about 1600 km^2 with a volume of about 6 km^3 and an average depth of 3.8 m. They enclose more than 22 islands with areas between 0.2 and 926.4 km (Rugen) and totaling 1370 km^2. Along the coast and above the "shelf", the "territorial waters" are located with a maximum width of 12 n.m. which cover an area of more than 9000 km^2. Partly, the "fishery zone" extends behind the border of the "territorial waters".

Impacts on and use of the coastal waters

There are many different and partly conflicting interests which make use of the coastal waters and/or contribute to a permanent stress towards them. These include fishery, recreation, navigation, industry, agriculture and nature conservation.

Between 50 and 60 thousand tons of fish, mainly herring, are caught annually by fishing vessels in the coastal waters. In addition, some fish farming was noticable for the bodden waters

(1987: nearly 800 t of rainbow trout).

The coastal district and the adjacent waters are of great importance for the port management and sea transport. In 1988, in the three seaports more than 25.52 x 10^6 t of goods were shipped in 5,976 vessels (Rostock 20.74, Wismar 3.76 and Stralsund 1.02 x 10^6 t)--mainly fertilizers, ores, metals, oil and related products, coal and coke, cement, and other chemical products. After 1989, shipping has been reduced drastically by about 50% with increasing shares for ferry lines and transportation of military equipment of the Russian army. The use of the coastal waters for sea transport requires the development and permanent maintenance of the navigation channels and of the port construction. Considerable amounts of contaminated dredge spoil are produced. For instance, from 1985 to 1990, about 11 x 10^6 m^3 of mud and sand have been dredged in the coastal waters, mainly for maintenance purposes. Development dredging was only minor. Muddy material was spoiled exclusively on land-based sites whereas relatively clean sand or gravel was dumped at selected sites into the sea again. Partly, in the past it has been used to re-build dunes and other coastal protective structures. In addition, more than 500,000 t/yr. of sand and gravel are extracted from the sea bottom for construction purposes on land. The exploitation of existing reserves in oil, heavy minerals, Fe/Mn accumulates or other sub-marine resources is not in sight in the near future.

The coastal waters have a special meaning regarding recreation purposes. The former district of Rostock (population in 1988: 916,500), which extended over the entire coastline of Mecklenburg-Vorpommern, had more than 54 camping sites with a capacity of 98,200 persons. In 1988, 806,800 persons were counted who spent at least one night at those places. Altogether, 3,463 million vacationers visited the coastal district in 1988. After 1989, the number of tourists has decreased considerably but is expected to increase again in the coming years. There are many plans now to extend the capacity of existing marinas and to build new marinas in the coastal zone.

Very often, agriculture is to be considered the key factor regarding the degree of possible impacts on coastal waters by contaminants. In 1988, 68.5% (4,851.5 km^2) of the coastal district were used by agriculture, mainly as arable (3,720 km^2, cereals, potatoes, sugar beet, oleaginous fruit) and grassland (1,022 km^2). In the same year, 64,800 t nitrogen and 12,900 t phosphorus were delivered as mineral fertilizers to the farmers. The application of pesticides for the former district Rostock was estaminated at 2,472 t (72% herbicides).

Frequently, fertilizers and pesticides were stored inadequately resulting in great losses to surface waters. (Officially the last application of DDT in agriculture occurred in 1978--at least in the coastal district--to protect the crops against the

"Rapsglanzkafer" (rape shining bug). Thereafter, exceptions were made only seldom to fight pests in forestry. In one special case, between 50 and 70 t of DDT may have been applied in 1983 on the territory of Mecklenburg-Vorpommern. Possibly, this could be the reason for the increasing DDT residues observed in fishes from some Swedish lakes during that period. For wood preservation, until about 1986 some formulations were commmercially available in which together with PCP ("Hylotox IP") and HCHs ("Hylotox 59") DDT was present, too.). Besides a certain fraction of the applied mineral fertilizers and pesticides, a part of the manure which stems mainly from the intensive breeding of cattle and pigs may also be washed into tributaries of the bodden waters and ultimately reach the Baltic Sea. In the district of Rostock in 1988, the stock of domestic animals included nearly 0.41×10^6 cattle, 1.0×10^6 pigs and 3.6×10^6 poultry. Often, due to the intensive breeding technology and the limited storage capacity, a great amount of liquid manure had to be brought out before the recommended 90 days aging even under sub-optimal conditions (state of the soil, meteorological conditions, season).

Until 1989, the main industries in the coastal district were the food industry (38.4%; fish and meat processing, sugar and starch production), mechanical and vessel engineering (30.4%; 4 major and some smaller shipyards) and the energy and fuel industry (11.2%, see nuclear power plant "Nord" at Greifswald-Lubmin). The percentage of the chemical (8.1%; mainly nitrogen fertilizer plant in Poppendorf in the vicinity of Ropstock) and other environmentally relevant industries were low.

The industrial share of the organic load to the Baltic Sea from the territory of the former GDR (main area of Mecklenburg-Vorpommern, parts of Brandenburg and Sachsen) was 22% (1987):

Industry	10^3t BOD_5/year
food	4.6
chemical	2.8
paper	1.3
textile	0.8
	9.5

Due to shut-downs, production cuts and technical measures for load reduction at 30 industrial sites, this number decreased to only 7.8×10^3 t BOD_5 until 1990.

The German Baltic Sea coastal area is one of the most prominent large-area landscapes in Germany. In order to safeguard valuable habitats with their unique flora and fauna, wildlife sanctuaries, natural preserves and wetlands have been declared protected areas of which at present 40 exist, including 18 wildlife preserves,the national parks "Westpommernsche Boddenlandschaft" and "Sudostrugensche Biospharenreservat", the wildlife reserve

"Usedom/Oderhaff", and the protected wetlands "Wismarbucht", "Salzhaff", "Greifswalder Bodden" and "Strelasund. At the former GDR's coast, there has already been a considerable reduction in existing natural floodlands as a result of the dyking of coastal swamps over several decades. Consequently, the self-purification power of the coastal landscapes was eliminated stepwise eliminated and the species diversity was reduced. The area impacted by such means is on the order of 20-50,000 hectares.

Input of contaminants

The German catchment area of the Baltic Sea is distributed as follows:

		coast length (km)	freshwater runoff (km^3, in 1990)
Schleswig Holstein	18%	535	2.0
Brandenburg & Sachsen	22%	0	0.6
Mecklenb.-Vorpommern	60%	1470 (340)	1.9

About 23,920 km^2, or 22.1% of the former GDR's territory and 1.5% of the total Baltic sea catchment area (1,721,233 km^2); drains into the Baltic Sea. This area includes the total coastal district of Rostock (7,075 km^2), about 34% of the district of Schwerin (8,672 km^2) and a major part of the district of Neubrandenburg (10,948 km^2). In addition, the German parts of the catchment areas of the rivers Odra (3.7% = 4,399 km^2) and its tributary Lausitzer NeiBe (28.9% = 1,225 km^2) are considered in this estimate. From those surface waters delivered to the bodden waters and the adjacent Baltic Sea, more than two - thirds come from nine rivers with >1 m^3/s, namely Warnow and Peene (23.9 m^3/s each), Uecker (11.5 m^3/s), Stepenitz (7.3 m^3/s), Recknitz (5.2 m^3/s), Wallensteingraben (4.4 m^3/s), Zarow (4.1 m^3/s), Barthe (1.6 m^3/s) and Ryck (1.3 m^3/s). The remaining influx was realized through small brooks, ditches and diffuse inputs. As a pecularity, all of the mentioned rivers do not enter the Baltic Sea directly but via the boddens and haffs which act as pre-purification basins and thereby as additional sinks for all types of contaminants.

The flushing properties of the bodden and haffs differ considerably. The most limited water exchange with the Baltic Sea is noted for the Kleiner Jasmunder Bodden inside the island of Rugen. It follows the innermost part of the Darb/Zingst bodden chain (Saaler Bodden/Ribnitzer See). The other water bodies of this bodden chain and the other inner boddens of Rugen exchange their waters with the Baltic Sea about up to 8 times per year. It follows the Kleines Haff (9 x), Greifswalder Bodden (12-14 x) and the Unterwarnow (26 x). Due to the water exchange conditions and the load patterns some of the boddens must be considered "polytrophic", i.e. the inner boddens of the Darss-Zingst "bodden chain", the Kleiner Jasmunder Bodden", the lower Warnow river, the Peene river and the Oderhaff.

There exist only a few data on the input of contaminants into the bodden waters and further into the Baltic Sea. Today, the main problem is the organic load by wastewaters of municipal, agricultural and industrial origin, and to a minor part by fish farming. The connection to public sewage systems and treatment plants in the former GDR's catchment area to the Baltic Sea may be indicated by the following numbers (in %):

	mean	>20,000 equiv.	<20,000 equiv.
sewerage system	71	92	30
treatment plants	-	86	23

Only 12% of the sewage has undergone biological treatment, the remaining part was treated mechanically. (In Schleswig-Holstein, 85% of the population is connected to mechanical/biological waste-water treatment).

A secondary load is connected with the input of micro-nutrients, i.e. nitrogen and phosphorus compounds causing eutrophication and even hyper-eutrophication in some innermost parts of the boddens (e.g., Saaler Bodden). In Table 1, the estimated loads from the districts of Rostock, Schwerin, and Neubrandenburg are listed. To get an impression of an approximate "total load" from the former GDR's territory, the percentage of the catchment area of the rivers Odra and Lausitzer Neipe have been considered as they would contribute those contaminants in the same relative amounts per real unit.

The numbers in Table 1 are by no means complete because an additional input, especially of nitrogen compounds, via atmospheric routes must be taken into consideration. Currently, there are no such data available for an assessment of phosphorus. However, for nitrogen an East German atmospheric input of roughly 38,000 t, or about 12% of the total atmospheric input to the Baltic Sea, was estimated by Iversen et al. (1989). The changes in energy production and in motor traffic have caused changes in the near-field atmospheric loading patterns for the coastal region and its tributaries. The load by fine Pb dust is expected to decrease by 60% from 1989 to 1992 due to the increasing use of cars with catalysts and the further reduction of lead in gasoline. Between 1988 and 1992 the emission of lead decreased in Germany from 940 t to 200 t/year. On the other hand, the increasing number and use of cars has increased the NO_x emission significantly in the "new countries" since 1990. The same effect is expected by the replacement of nuclear power plants by conventional coal-fired power stations.

The main part of the load by organic compounds and phosphorus comes from municipal sewage waters. For nitrogen, the input from agriculture is in the same order as that from those sources. The industry contributes about one quarter of the organic load and less than 10% of the nutrients. Less than 10% of the wastewaters are released directly into the Baltic Sea. The remaining part must pass the "filter" bodden waters before it approaches the open sea.

The low efficiency of sewage treatment may be demonstrated by the former situation in the district of Rostock which was symptomatic for the whole catchment area: 99.6% of the population was connected to the central drinking water network. However, only 71.4% had access to a canalization system for sewage. Sewage treatment was available only for 64%. In addition, it should be mentioned that the sewage of most of the bigger towns (e.g. Rostick (249,000), Stralsund (76,000), Bergen (19,000), Sabnitz (14,000),Bad Doberan (12,000), Rerik (<10,000) and Wolgast (17,000), was only mechanically treated. Twenty-one sewage treatment plants--out of about 96--provided some kind of biological purification, including--since 1989--Wismar (58,000 inhabitants) as the only bigger town and Grevesmuhlen, Neukloster, Gohren, Boltenhagen, Kuhlungsborn, Dorf Mecklenburg, Schonberg and Zierow. Some small treatment plants (Dorf Mecklenburg, Boltenhagen) applied phosphate precipitation in a pilot phase. Most of the bigger plants had their own treatment system, partly with a satisfactory efficiency (e.g. fertilizer plant Rostock-Poppendorf or nuclear power station), but sometimes with very low efficiency as well (e.g. Faserplattenwerk Ribnitz-Damgarten--settling ponds). A special problem was the sugar industry, mainly with the plants in Stralsund, Barth or Tessin which released 316,000, 15,000, and 18,000 "EGW"x), respectively.

Thereby, during the "sugar campaign", the organic load from the sugar factory in Stralsund was alone four times higher than from the common municipal sewage.

The inner and outer coastal waters of the GDR seemed not to receive any significant load of toxicologically relevant organochlorines. However, this statement must be taken with caution because there are only very few data available and there have never been special regular monitoring activities with regard to those compounds. In 1980, investigations on DDT in the Darb/Zingst bodden chain revealed mean values of 1.4 ng/L for water and 22, 44 and 15-80 ng/g dry weight for sediments, plankton and fish, respectively. PCB's were found there in quantities of 5.9 ng/L (water), 10 (sediment) 8 (plankton) and 5-46 ng/g dry weight (fish). Until 1989, the river Warnow was irregularly investigated for some chlorinated hydrocarbons (toxaphene, DDT, DDE, PCB's, lindane) but only lindane was found in "remarkable" concentrations. In 1988, a maximum in the PCB content of cod liver was found for the Mecklenburg Bight. This increase from 2 to 9 ug/g could be attributed possibly to the extraordinary situation in the Belt Sea during that year.

Mud sediments of the hypertrophic Saaler Bodden showed lindane contents between 0.5 and 700 ng/g. The sum DDE/DDMU went up to 5 and even 14 ug/g close to the inlet of waste waters from the town Ribnitz-Damgarten and the wood-processing plant, respectively. Some other compounds were mainly below the detection limit and showed maximum content of only 50 (PCB's, methoxychlor) and 0.5 ng/g wet sediment (endrin).

Since 1983, at intervals of one or two years, investigations on the burden of the coastal waters with petroleum hydrocarbons and metals have been carried out. The results do not show any extremely high contaminant levels. In accordance with the infrastructure and known load patterns, the Unterwarnow and the Peenestrom/Kleines Haff, influenced by inputs from rivers Odra, Uecker, Peene and Zarow, were identified as "areas of special concern". From studies carried out in 1989,the total annual input of heavy metals into the bodden waters which partly could reach the Baltic Sea as run-off from the former GDR's territory was preliminarily estimated to about 105 t Fe, 50 t Zn, 0.6 t Ni, 0.5 t Cu, 0.3 t Pb, 0.07 t Co, 0.015 t Cd and 0.01 t Hg.

Despite their relatively low burden with contaminants of special concern, rivers of the district of Rostock draining into the Baltic Sea are of significantly reduced quality due to their organic and nutrient loads. In 1990, of 823 km of river investigated, only 0.6% were classified--on a six class scale considering criteria of the organic load--as "very good" (class "1", drinking water quality), 23.7% as "good" (class "2", limited use as drinking water), 44.2% as "medium" (class "3" reduced use for bathing purposes, for drinking water preparation sophisicated technologies needed), 24.9% as "faulty" (class "4", no use for drinking water preparation, fishing or bathing; for industrial purposes with limitations usable) and 1.6% as "bad" (class "5", only for industrial use after previous treatment). Because the cleaner water is always found in the upper parts of the rivers, a classification regarding the water <u>volumes</u> would certainly result in a much more negative picture. The same happens if the load with certain contaminants, in most cases the nitrate content (threshold for drinking water 50 mg/1) serving as dominating parameter, is used for classification.

Special problems

1. Greifswalder Bodden

The Greifswalder Bodden (average depth 5.6 m, salinity 7.28 PSU) is a major "growing area" for herring. About 25% of the bottom is covered by muddy sediments with redox-potentials equal to or below zero at the interface with the water. The nutrient load is due to the agricultural run-off and sewage (Greifswald via Ryck and Stralsund via Strelasund) but mainly caused by the Peenestrom, a combined outflow of the rivers Peene, Uecker, Zarow and especially of the Oder. Until building the nuclear power station, the Peenestrom touched the Greifswalder Bodden only before draining into the Baltic Sea. Since 1973,increasing amounts of the nutrient-loaded Peenestrom were taken as cooling water for a nuclear plant--finally nearly 100 m^3/s for four blocks--and re-injected with about 10°C higher temperature into the more central bodden. From satellite images this plume of warmer water was identified only for 2-3 km distant from the point source. (Already in 0.5 km distance the temperature difference dropped to less than 1°C.

The volume of nutrient-rich cooling water injected annually (3.2 km^3) corresponded closely to the total volume of the bodden (2.96 km^3). However, the bodden waters are exchanged between 12 and 14 times per year with the adjacent sea. Therefore, the effects of this nutrification were limited. Investigations carried out between 1974 and 1989 did not show significant changes either in the species composition and biomass of the phytoplankton or in the Secchi disc depth (1962-89). During the spring bloom 3-35 * 10^6 (maximum 80 * 10^6) cells/L and a primary productivity up to 1.4 g $C/m^2/d$ were observed.

Due to a lack of comparable data from the 1950s and 1960s, no clear trends or tendencies could be found until now for the phytoplankton, although at least some observations indicate long-term changes. For instance, the lower boundary for the growing of macrophytes has moved up from 7-8 m in the 1930s to 4-5 m for today. In addition, Fucus vesiculosus and Fucus serratus declined at the German coast, but especially in the Greifswalder Bodden. The causes for this observation are not yet fully understood. At least, it seems not to be directly coupled to eutrophication because Fucus belts are growing perfectly in the vicinity of nutrient- rich inlets.

Presently, all four blocks of the nuclear power station are shut down because of unacceptable security risks. The further fate of these blocks and of an additional four which have been planned or were already under construction,has not yet been decided. Regarding radioactive contamination, there has never been an observed impact on the Greifswalder Bodden in the past.

2. Sanitary conditions at the coast

As a precaution, on 2.75 km (0.8%) of the 340 km outer coast, the responsible authorities proclaimed a ban for bathers. This was due to 8 inlets of treated and untreated sewage and of contaminated run-offs from the agriculture. The "safety stripes" around those point sources extend between 150 m and 750 m. From the inner coast, nearly 100 km had been closed officially for bathing purposes due to sanitary requirements. This included parts of the Salzhaff (Rerik, 0.6 km), the Saaler Bodden including the entire Ribnitzer Sea (32 km), Barther Bodden (8 km), Strelasund (5 km), Wieker Bodden (15 km), and--since 1972--the entire Kleiner Jasmunder Bodden (39.35 km, which receives sewages from Bergen and Prora). Here, a catastrophic fish kill comprising all species and nearly most of the stock was noticed in April 1990 due to an intensive bloom of a toxic algae (Prymnesium parvum). According to those official numbers, only about 10% of the inner coast as e.g., harbor areas, the Unterwarnow/Rostock, parts of the Peenestrom/Kleines Haff and of the inner Wismarbucht were generally not made available for bathers due to other uses and/or heavy contamination.

Based on sporadic measurements, as a rule at the beginning of the holiday season, it was claimed that there is only very seldom an indication of actual fecal pollution. Bathing at the outer coast was, with the exception of areas close to those mentioned contaminated inlets, considered "non-problematic". Measurements in 1984-89 at the beaches of Warnemunde, close to Rostock, have shown bacterial numbers of < 100/ml (22°C, 48h). The number of coliform bacteria (Eschericia coli) was always below the standard (< 20/ml). Bathing limitations at the inner coast were partly due to limited visibility. Below 50 cm visibility, bathing was not allowed.

According to official sources, there is no confirmed indication of epidemic cases due to bacterial water contamination. (The frequently described "Haff" disease is probably related to exceptional and toxin-releasing algal blooms. In addition, there was always some discussion and speculation that the unusual frequent occurence of other more severe diseases, e.g. Meningitis in Stralsund in the mid-1970s, may have spread via contamination of inner coastal bathing waters by improperly treated sewage.)

3.Deterioration of benthic ecosystems off the former GDR's coast

Since the beginning of the 1980s, the oxygen declined in the Lubeck Bight and Mecklenburg Bight below 20 m water depth and thereby the benthic ecosystems changed significantly. This may not--first of all--be due to the presently observed stagnation period for the water exchange between the Baltic Sea and the North Sea because several times the bottom waters of this area are replaced by "new" more saline waters from the Kattegat/Skagerrak--at least up to the Darss Sill. The oxygen deficiency is developed annually with the summer plankton bloom from about July to September. Sometimes, at the beginning of August, close to the bottom (24 m) near oxygen saturation was still registered. After the onset of stratification, the oxygen may be consumed entirely in only 14 days.

The overall tendency to a deterioration regarding the bottom flora and fauna peaked in 1988. Off Kuhlungsborn, oxygen deficiency and even "zero values" were already met at the 12 m depth line. The "desert" which since 1983 has covered the bottom of the Lubeck Bight below 20 m and great parts of the Mecklenburg Bight spread accordingly. In 1989, there was no re-colonization by mussels observed. (A causal link to the exceptional

Chrysochromulina polylepis bloom of May/June 1988 in the Kattegat/Skagerrak area and the influx of bottom waters with the remains of that bloom seems questionable because the biomass of that flagellate to be degraded was very low.)

In the central part of the former GDR's share of the Arkona Basin, drastic changes were observed during the last years, too. Regarding the macrofauna, only some very rare opportunistic molluscs were met, favored by the lack of other species. In June 1989, on the bottom of this basin with a remote video camera typical spots of sulphur bacteria (*Beggiatoa*) were observed on a black organic layer.

There are several data available which allow conclusions on long term trends. For instance, in the Arkona Basin Macoma balthica increased about ten times since 1950 and *Pontoporeia affinis* five times. The same trend is seen for the total macro-zoobenthos biomass:

1925	1950	1957	1967	1980
17	30.5	50-60	200	204 g/m^2 wet weight

In the Mecklenburg and Lubeck Bights, the changes of the environmental conditions in the last ten years also caused changes in the macrofaunal species composition. For instance, below 22 m,an *Abra alba* community was replaced by the more opportunistic *Macoma* community. However, it has been stated that in relation to observations from 1932, surprisingly, the overall basic structure of this benthic ecosystem did not change so much. Maximum values up to nearly 700 g/m^2 wet weight in the Wismarbucht clearly indicate eutrophication.

4. Nutrification

Investigations on nutrients carried out between 1973 and 1988 showed surface phosphate values in winter (January/February) between 1.2 and 1.7 umol/L for the Lubeck Bight, 0.9-1.3 umol/L for the middle part of the outer coastal waters and up to 3.8 umol/L in the Oder Bight. In summer (July/September), the values drop below the analytical detection limit. In the inner coastal waters, the highest concentrations of phosphate occur in the vicinity of wastewater and river inlets. Despite consumption by phytoplankton, the summer values (5-12 umol/L) exceed those of the winter period (4-5 umol/1). In the eastern bodden waters, a mean annual increase of 0.10 (Greifswalder Bodden), 0.13 (Peenestrom) and 0.16 umol PO_4 - P/L (Kleines Haff) were recorded for the time span 1973-88. (Partly, this increase may be due to an increase of phosphates in municipal sewage. Two or three decades ago, about 2 g PO_4-P were released daily per inhabitant. Today, this value has changed to between 4 and 5 g, mainly because of the increased use of P-containing detergents in the household). In the Mecklenburg Bight, between 1971 and 1989, an annual increase of the phosphate winter concentration of 0.014

umol/L was derived from the regression lines. For the central Arkona Sea, the corresponding value for the period 1964/89 was 0.021 umol/L.

The mean (1973-88) nitrate winter concentrations of the surface waters are about 6-7 umol/L for the central part of the outer territorial waters. These concentrations may increase towards the inner Lubeck Bight (18 umol/L and Odra Bight (60 umol/L). In the inner coastal waters, maximum values were observed in the Unterwarnow (350 umol/L) and at the mouth of the Peene (250 umol/L). During the summer, there is still enough nitrate in the water to guarantee a high production of phytoplankton (Unterwarnow 20-40, Kleines Haff 15-30, Peenestrom 5-15 and Odra Bight 4 umol/L).

For the western part of the former GDR's territorial waters, an increase of nitrate from 5 (1973) to about 14 umol/L (1988) was found for the winter period. Since 1985, close to the mouth of the Warnow, additional nitrate inputs have been noticed from the waste water of the fertilizer plant. For the period 1971-89, in the winter water of the Mecklenburg Bight nitrate showed an annual increase of about 0.13 umol/L. The same value was recorded for the central Arkona Sea (1965-89). However, for these nutrient trends in the outer territorial waters, it should be kept in mind that the main increase occurred prior to 1982. Thereafter, values remained more or less level.

The higher nutrient load was reflected partly by tendencies for increases in the primary productivity and chlorophyll "a" values for the above mentioned areas. Whereas for the spring bloom no significant trend could be derived, the autumn blooms showed in the Mecklenburg Bight between 1982 and 1988 a clearly increasing trend for the chlorophyll "a" values.

Conclusions & outlook

In 1988, the Baltic Sea states agreed to aspire to a 50% reduction in the load of nutrients, metals and organic contaminants from their territories to the Baltic Sea until 1995. For the three "new (East German) countries" concerned, in the field of municipal waste water treatment, between 4 and 6 x 10^9 DM have been estimated to fulfill this requirement. (Requirement for the improvement of the municipal wastewater treatment in all five new East German countries: about 30 x 10^9 DM.)

To preserve the present state or approaching stepwise improvements regarding the environmental quality of the boddens, haffs and outer coastal waters, activities are needed in about the following priority order:

a) Measures in the field of agriculture, as e.g.
* cutting back the use of fertilizers to the quantities directly required for the nutrient balance in the soil,

* reduction of the livestock to 1 to 2 large cattle units per hectare,
* large-scale cultivation of vegetable and animal production,
* drastic reduction of the numbers of animals kept in mass

Aquatic Environmental Problems in Bulgaria

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Foreword

The identification and analysis of environmental issues in the countries formerly known as the Eastern Block poses great problems, both for the countries themselves and for those who wish to solve them. The lack of reliable data and experience with appropriate management tools have created a substantial amount of confusion in dealing with environmental problems in Central and Eastern Europe. Free exchange among the eastern and western countries in solving water-related environmental issues is now taking place. This is based on the increasing interest of environmentalist citizen's groups, national and international nature preservation institutions, agencies and organizations. It is to be hoped that these initiatives, besides the quantitative and qualitative approach, will develop a framework for the future coordination of the water environmental scientific research and management, making its use widely available to all concerned with the future of the world water resources.

Recent research shows that the main pollution of the surface waters in Eastern Europe is associated with heavy industry, agricultuiral malpractices, and sewage treatment (1). Apart from energy-based pollution, runoff from livestock sheds, silage stores, and forestry operations are common serious problems. Pesticide and nitrate levels are also causing considerable concern. However, perhaps the most serious degradation of the water systems comes not from energy or even agriculture, but from untreated sewage and industrial effluents rich in heavy metals and toxic chemicals. The Global Industrial and Social Progress Research Institute in Tokyo, shows the following water pollution situation in East Europe at a glance. Here are the terms used to designate the six former East European members of the Council for Mutual Economic Assistance: East Germany (EG), Czechoslovakia (CZ), Poland (PO), Hungary (HU), Bulgaria (BU) and Romania (RO).

Countries	EG	CZ	PO	HU	BU	RO
Water pollution/significance	**	**	***	**	**	**
Nitrates/agrochemicals	++	++	++	+	+	+
Sewage/bacterial infection	++	++	+++	+	+	++
Industrial and municipal	+	++	+++	+	+	+
Mining waste/refinement	++	++	+++	+	-	+
Acidification	+	+	++	-	-	-

The key for analyzing the above data is: (*,+)=catastrophic; (**,++)=serious; (***,+++)=major; (****,++++)=caFtastrophic and (-) means that the problem is either negligible or being effectively managed.

According to this survey, Bulgaria is in a rather favorable position with regard to water pollution. However, the research has pointed out that the middle and lower reaches of virtually all large rivers are either organically dead or fast becoming so. There is widespread pollution of metals, nitrates, oil derivatives, and detergents. Bulgaria contributes new sewage, oil, chemicals and an array of industrial pollutants to the Black Sea, which is now dangerously polluted.

Significance of the aquatic environmental problems

The global character of the pollution of the world's water resources, either directly or indirectly, to one degree or another, affects the interests of all countries. Every national economy is increasingly experiencing acute negative effects of the pollution of its "own" environment, when in fact, the water pollution is coming from neighboring states. This is all the more valid for relatively small countries with limited natural resources. So, it is extremely important for countries such as Bulgaria, which is poor in water resources, but rich in other resources. The ecological interdependence of the countries on a regional and planetary scale is a relatively new phenomenon in the development of modern society and has become an integral part of international relations. Today, environmental protection is a universal problem--the problem of our century. Water is an extremely complex part of the environment with many conflicting functions in regional and national economics. Due to population growth, industrial and agricultural development, increased pollution and the impact of climatic varability and changes, the reliability of water supply may decrease substantially in various parts of the world causing serious social, economic and political problems. The necessity of close relationships between water environmental specialists from all over the world is obvious in order to achieve a favorable solution to the rising aquatic environmental problems (12,a).

Water resources information systems

As pointed out by the Ministry of Environmental Protection in Bulgaria (2), the measurement and evaluation of the surface water is based on information from control monitoring points throughout the country, allocated in river basins, lakes, reservoirs and along the Danube River and Black Sea coast. The Ministry of Environmental Protection has established the Unified National Control System of Environmental Protection. Different units for surface and groundwater are established as parts of this system. From the total number of 50 river water basins, 25 have been selected for monitoring with 199 observation points. The groundwater unit consists of 276 points (springs, tube wheels and observation wells) distributed over the areas depending on the physical-geographical and geologic-hydrologic conditions.

Surface sampling usually takes place twice monthly and at other times less than 12 times a year. Only seven to eight parameters have been monitored, which shows that water quality characteristics have not been completely monitored. Since the sampling is done by different agencies, there have been discrepancies in the concentration values of some parameters. Also, information about petroleum pollution is not available.

There is also a program in place for groundwater monitoring. The parameters to be monitored are chlorides, sulphates, nitrates, and general mineralization. The periods of sampling range from 1 to 12 times per year. The monitoring points are distributed according to the hydrogeology of the basins.

Surface water evaluation

Until now, surface water quality evaluation depended on the separate sampling of elements at separate control points. In order to achieve complex water quality evaluations, reliable information about pollutant concentrations were generalized from related water bodies by taking purification technology into consideration. The mechanical treatment of water is characterized by the presence of undissolved substances. The chemical water treatment may be characterized by COD (chemical oxygen demand), which is equivalent to the biochromatic oxidation. Due to the absence of the above data, in the present complex the evaluation method used was the permanganate oxidation as an index of the chemical treatment of polluted water. The biological oxygen demand on the fifth day (BOD-5) characterizes the degree of biological treatment. The specific elements such as lead, arsenic, chromium, phenols, and iron are also measured and included in the complex index (K). This index was developed by multiplying the average value which has a 90% duration by the number of the indices which characterize the different groups. In such a way, all basic parameters of every river valley may be expressed by the above defined complex index and the ratio between the clean control sites and their total number. The control sites considered to be the most characteristic are those within the range of the maximum and minimum water pollution, including the last control point at the end of the river valley. In this report, the period 1988-89 is under review. Some of the results are:

- Veleka River has been "clean" at every control point;
- Danube River has been clean at 10 out of 11 control points;
- Rousenski Lom, Provadiiska, Aitoska, and Mesta River, did not have a single clean monitoring site.

The overall number of the clean sections increases due to the construction of a significant number of purifying plants, but their outputs are not yet sufficient to have reached projected goals. The maximum pollution of the river basin shows a variation of the complex index from 5.31 to 32.39 for national rivers. On the basis of the values of the complex index with 90% duration, surface water pollution can be classified as follows:

Value of the Complex Index	Estimation of the degree of water pollution
Below 1	Clean
1-2	Slight pollution
2-6	Intermediate pollution
6-12	Heavy pollution
Above 12	Dangerous pollution

According to the above classification the major Bulgarian rivers can be evaluated as follows:

Rivers	Complex Index
Veleka	<1
Osum, Provadiisva, Mesta, Struma and Danube	2-6
Ogosta, Iskur, Vlt, Tundja, and Maritsa	6-12
Iantra, Rusenski Lom, Kamchia and Arda	Above 12

Note: There are no rivers within the range (1-2) of the complex index.

The main reasons for the water pollution can be summarized according to rivers:

Rivers	Main Reasons for Pollution
Ogosta	Farm stock
Iskur	Insufficient treatment works
Vit	Paper plant, farm stock, etc.
Iantra	Sewage problems, sugar plant
Rousenski Lom	Antibiotic plant, sewage, farm stock, etc.
Provadiiska	"Devnia" industrial complex
Kamchia	Urban and industrial sewage
Aitoska	Sugar plant, sewage
Tundja	Urban and industrial sewage
Maritsa	Urban and industrial sewage
Arda	Flotation plant, sewage
Mesta	Paper plant, sewage, etc.
Struma	Insufficient treatment works, urban and industrial sewage

* Veleka (the only clean river)

Making comparisons with previous years, it can be concluded that the rivers Ogosta, Iantra, Provadiiska, Tundja, and Maritsa are improving. The water conditions of the Kamchia and Mesta rivers remain the same. Conversely, the conditions of the Iskur, Osum, Rouslenski Lom and Aitoska rivers are getting worse.

Altogether, data in the specific indices are scanty. It is possible to say that lead was measured at some monitoring points on the Maritsa and on the Arda River downstream of the village of Vehtino; arsenic in Topolnitsa Dam and on some sites in Maritsa River; chromium in the Maritsa, Iskur, and Tundja Rivers; phenols in the Iskur, Vit, Iantra and Tundja river. The overall situation depending on the introduced complex index is presented on maps, showing the current and projected situation of river pollution in Bulgaria.

Danube River Basin

Special attention has been given to the Danube River, keeping in mind that it plays an essential role in the daily existence of 81 million people in the Danube countries and has fulfilled functions of great economic importance: transport route, source of irrigation water, cooling and processing water for industry, drinking water, electricity generation, fishing, tourism, and recreation. The relationship between the Danube River and the Black Sea should be also taken into consideration, keeping in mind that the Danube waters greatly influence the water quality of the western Black Sea (3).

Bulgarian stretch of the river

The Bulgarian stretch of the river is situated along the lower Danube from the Timok River mouth (845 km) to the east of Silistra, with a total length of 471 km. There are 11 hydrometeorological stations along the river within an average distance of 50 km from each other. The contribution of the tributaries along the river is approximately 154 m^3/s. The average annual water discharge increases from 5,727 m^3/s at Novo Solo to 6,300 m^3/s at Silistra. About 150 m^3/s are used for cooling of the nuclear power station "Kozlodni". The total amount of water used for irrigation, electric power, industry and drinking water from the Bulgarian port of the river is 1 x 10^9 m^3.

Water quality characteristics.

Except for accidental "disastrous" pollution caused by petroleum products, the waters with respect to the indices observed - oxygen regime, mineralization, biogenic elements, and specific toxic substances - are in category III, with respect to Bulgarian standardization which means that the water can be used for irrigation and industrial supply. Among the metals, the most dangerous elements are lead and manganese. A more detailed analysis of available data shows the following pollution:

dissolved substances	below Nikopol, Svistov and Rouse
cyanide	below in inflow of Iskur River
iron	above Lom, Kozlodui, Oriahova and Rouse
oxidation	below Rouse
hydrogen sulphide	below Lom and Silistra
ammonia	below Rouse
nitrate	below Rouse, Tutracan and Silistra
organic pollution	below Svistov
oil & petrol products	below Rouse

Since the construction of Iron Gates I and II, the turbidity of the river water has been reduced and downstream of Sivstov monitoring site is 40%. Because of this a sediment deficit has been created, and the processes of erosion and abrasion activated. The general analysis of the Bulgarian data leads to several conclusions:

- The basic water quality of the Danube is formed in the upstream part of the river before it reaches the Bulgarian border. Also, the water quality of the Bulgarian stretch of the river generally stays the same.
- The total mineralization and content of various toxic elements in the river waters has increased in the past 30 years.
- Organic pollution seems to show a slight increase near Silistra. The maximum level of organic pollution is observed upstream of Nikopol, downstream of Vidin and downstream of Rouse where the increase has been 15-25% during the last ten

years.

- Yearly pollution resulting from biogenic elements (nitrates, nitrites, ammonium, phosphorus, iron, etc.) shows that the maximum pollution coincides with the high waters of spring (April and May). Snowmelt and rain from fertilized areas are carrying biogenic elements into the river.
- Tributaries, industrial waste and sewage from Bulgaria have a local influence, about 5 km downstream and up to 150-200 m in width.
- Erosion and abrasion processes continued.

Radioactivity levels on the Danube.

The level of radioactivity of the Danube River depends on the concentrations of naturally occurring radioactive elements in the river water and on radionuclides of anthropogenic origin as well. Since 1988, the radioactivity level of Danube waters has been monitored by constant measurement of common alpha and beta radiation. According to the Romanian Bulgarian agreement, the water has been monitored jointly at two control stations--Novo Solo and Silistra-every three months.

In 1989, wastewater from the Kozlodui Nuclear Power Plant, which flows into the Danube with 7-15^{0}C higher temperature, showed a level of 0.029-0.036 Bk/L alpha radiation and 0.14-0.21 Bk/L beta radiation. It was found that this power plant did not affect the level of radioactivity in the Danube until 1989. The future planned project of a second nuclear power plant on the Danube River near Belene could cause additional thermal and water pollution (4). The total beta-radiation has increased from 0.16 at Novo Selo to 0.24 Bk/L at Silistra during 1989. Danube radioactivity monitoring is important because Danubian terrace waters are used for water supply.

Environmental program for the Danube River basin.

In the fall of 1991, in Sofia, Bulgaria, an environmental program for the Danube River basin was initiated with the joint efforts of a number of international organizations and the governments of the Danubian countries (3,5). The leading role in this activity belongs to the Global Environmental Facility (GEF) project of the UNDP, UNEP and World Bank, PHARE Program of the Commission of the European Communities (CEC), and the European Bank for Reconstruction and Development.

Other international supporting organizations include the European Investment Bank, Nordic Investment Bank, United Nations Conference on Environment and Development, La Foundation Cousteau Demerrage, USAID, Division of Water Sciences, and UNESCO. The main objective of the program is to support the development of water management structures and tools for internationally coordinated actions to improve the water quality of the Danube and consequently, the Black Sea. To insure effective and widespread support for the program, the public should be appropriately informed of the general objectives of the program. The main conclusions and priority actions of the Danube program are summarized in the bulletin of the Regional Environmental Center for Central and Eastern Europe (5) and they are based on the following basic set of management tools:

1) development and construction of Data Management System;
2) evaluating and increasing the compatibility of the water quality legislation, including water quality standards, their implementation and harmonization; and
3) development of an international, optimal, and cost efficient water quality monitoring program.

It is clear that the proposed management tools for the Environmental Management Program for the Danube River basin would support activities to overcome the major constraints on the development and implementation of an effective international management system. Also, we have to mention, that according to the survey carried out by the European Institute for Water, Brussels, 47 projects have been identified concerning different aspects of the Danube River basin (6). They were submitted by: European Commission (17), Regional Environmental Center in Budapest (11) PHARE program (10),and others (9), which includes the Cousteau Foundation, TEMPUS joint European project, etc. The International Center for Water Studies, Amsterdam (7) also shows that the Danubian countries themselves are trying to save the Danube region. A good example in this direction is the recently developed (Bulgaria, 1991) international database system called 'INFODANUBE' (8, 12b). The final version of this database is available at the Regional Environmental Center for Central and Eastern Europe in Budapest, Hungary (5). 'INFODANUBE' is a network of computerized databases linked together to describe the current ecological situation of the Danube River and what may happen to it in the future. A major national program for the Danube River basin has been established with the guidance of the Bulgarian Ministry of Environment (9).

Coastal water quality and the Black Sea

In the Bulgarian coastal region, about 645,644 m^3/day of waste water accumulates, from which 405,132 m^3/day (62.75 are from industrial discharge and 240,512 m^3/day (37.25%) are from sewage. Currently, 24 control points are established in order to monitor coastal and sea water quality. The observations are performed 1 to 2 times monthly for 20 physical and chemical indices and once per quarter for microbiological indices. During the summer months of 1989 an increase in organic elements was registered (oxidation and BOD_5), and, as a result of the increased bioactivity, a saturation with red seaweed was noticed. Also, the sanitary protection points in the Bourgas port area shows a permanent increase of 1.5 to 2 times above standards for all elements under control. According to the Appeal of the Independent Movement in Bulgaria, "Ecoglasnost", during the last two decades, the Black Sea has been in ecological disaster (10). "Permanently increasing organic pollution causes spreading and blooming of large amount of microalgae. The sea becomes a tremendous generator of biomass which dies, precipitates, rots, consumes oxygen from the water and causes eutrophication. Chemical pollution has also grown--oil spots take more and more of the Black Sea aquatory. Destruction of the littoral zone with its unique flora, and fauna continues."

Due to the large fresh water input of the Danube, its water quality is a particularly significant factor in the development of the Black Sea water quality. It is obvious that we must look at the Danube River and the Black Sea as a united ecosystem. Research shows that the Danube's loads into the Black Sea are many times higher than those of the Rhine River to the North Sea. Even, when a comparison is made between the input of the Danube into the Black Sea and the input of all Western European rivers into the North Sea, it is seen that the loads are approximately equal, but for the oil, the Danube load is even larger (11). Together with the loads of other inflowing rivers (Dnjeper, Dnjestr, Don, etc.), the Black Sea must process a gigantic quantity of nutrients and xenobiotic substances. In the long term, it is difficult to imagine that the system will be able to endure this.

Bulgarian Groundwater Quality

Groundwater is an essential resource for Bulgaria. The special features of groundwater, such as the way it forms and spreads, physical-chemical, biological and radiologic compounds and usage, have made it a relatively independent water resource. Groundwater flow (the natural reserve of groundwater) is estimated at about 6.5 x 10^9 m^3/yr. and about 30% of the surface water flow. Use of water resources is estimated to be nearly 3 x 10^9 m^3/year. Bulgarian land, according to the hydrogeological map, is divided into 16 hydrogeologic regions, with a control network consisting of 276 observation points. These monitoring points are distributed according to the hydrogeological basins. On the basis of the gathered information from these points, some general trends and conclusions have been drawn:

1) A continuously high level of nitrate pollution was recorded in the Loudogorie and Dobroudza regions. It was caused by the excessive use of nitric fertilizers which have infiltrated the soil and affected ground-water.

2) The level of chloride above the standard was registered in the lowlands along the Danube and the Black Sea.

3) Sulphate pollution was higher in many areas, combined with chloride and nitrate pollution, which usually indicated the

presence of pollution such as improper fertilization procedures, etc.

The evaluations made are of a tentative nature. Another, more detailed investigation of pollutions in these vital areas is needed.

Conclusion

It is obvious that the waters of Central and East Europe from the Baltic to the Black Sea are suffering from decades of abuse and neglect. In this critical time, only the international cooperation and transfer of new, environmentally clean technologies from Western to Eastern countries could give a fresh air to the exhausted nature. The research done through the Energy and Environmental Program (1) summarizes, "The West can help East Europe environmentally in many ways and encourage those with the political will to bring about environmental enhancement. Meanwhile, the West can surely learn lessons applicable to its own environmental predicaments. But it cannot, and should not try, to pressurize the East Europeans to do everything too quickly or too dogmatically. The environmental situation in East Europe is going to take decades to put right and some countries will perform better and more quickly than others. The long-term prospects for environmental enhancement are good, but it is important that everyone concerned embarks upon the right roads to enhancement even if it takes a little more time to map out the routes."

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REMARK: All unpublished papers available upon request.

AQUATIC ENVIRONMENTAL PROBLEMS IN RUSSIA

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Preface

Pollution problems in most of Russia's seas, lakes, rivers and other aquatic systems are in a catastrophic state. There are some areas, particularly shallow lakes and seas, where irreversible changes have already occurred; for example, the northwestern Black sea, the Sea of Azov, and the Caspian Sea. A number of other water systems are in a pre-critical state.

The presence of metals in the water, highly toxic contamination due to non-decomposing chloro-organic compounds, extremely high concentrations of perilous substances on the water surface (such as oil products), bottom silting (leading to the poisoning of shallow areas by hydrogen sulfide), and increasing inputs of organic wastes, each act as a catalyst in the process of the degradation of saline and freshwater ecosystems. In shallow water areas especially, the above pollution problems often give rise to the wholesale death of various species of animals and fish.

It should be noted that the present situation is the inevitable result of the regional egotism of governmental leaders, a lack of interdisciplinary coordination, and a passive, irresponsible attitude by the public at large. I am deeply convinced that only drastic measures through new cooperation between scientists and government administrators are likely to yield practical results within a relatively short period of time. The keystone of success is also sure to be international cooperation in order to use the experience and expertise of all nations in the development of strategies to remediate some of the more severe environmental problems in my country, and to prevent their recurrence and proliferation. The Marine Sciences Research Center has a great deal of experience in solving aquatic problems, and I am glad that such a distinguished organization will head our cooperation efforts.

In Russia, as well as in other Eastern European countries, many water bodies--both marine and fresh water--suffer severely from eutrophication, toxic pollution, and water diversion. Both eutrophication and toxic pollution are mainly connected with waste disposal, as a result of discharging untreated municipal and industrial wastes into receiving waters. Fertilizers, atmospheric deposition and chelators in detergents may also be significant sources of pollution.

Now, I would like to inform you about some aquatic problems in Russia. First, a word about the usual state of the aquatic environment; then I will give some details about some of the most serious water problems of my country. Our water resources include the seas, lakes, rivers and many manmade reservoirs used for various tasks.

While the eutrophication process is directly connected with pollution, I'd like to start with the more common problem of discharges of toxic pollutants into the aquatic systems of Russia.

Pollution of fresh water

Note that hereafter it is convenient to use MPC Units to denote the Maximum Pollution Concentration. In 1990, 2,236 bodies of water including 1,949 water courses (rivers, channels and collecting basins) were determined to have unacceptable levels of pollution.

According to reported observations, the quality of surface waters has decreased in comparison to 1989 conditions, and an annual increase in the number of situations with unacceptable levels of water pollution (at or exceeding 10 MPC) was detected. The total number of situations in 1991 were 1,221 (an increase of 27%).

Extremely high levels of water pollution (levels exceeding MPC by 100 and more times) were registered 443 times; 84 cases of emergency pollution and 33 cases of fish kills were registered in 1989.

Fig. 1 show the trends of the numbers of emergency discharges, extremely high pollution (EHP), high pollution (HP), and fish kills for the period 1985 - 1989. The increase in the number of accidents accompanied by pollutant discharges into water bodies are clearly seen.

Major government departments whose activities were implicated in pollution activities include:

	%EPC
1. Ministry of Housing Facilities and Public Utilities	-26%
2. Non Ferrous Metallurgy	-24%
3. Timber Industry	- 7%
4. Chemical Industry	- 6%
5. Others	-20%
6. Undetermined sources	-17%

For example, in 1988, among the 30 million tons of pollutants discharged into the hydrosphere of the USSR were 82,000 tons of pesticides and 58,000 tons of petroleum products.

TABLE I

Some statistics of pollutants measured in the European part of Russia in 1990 (with concentrations exceeding MPC):

Region	Contaminant	Peak conc (x MPC)	MPC mg/L
Upa river (Tula region)	Phenols	36	(0.001)
Rivers of Archangelsk region	Lingin	25-330	(1.6)
	N-ammonium	92	(2.0)
	Oxygen deficiency (Timber Industry)		
Moscow River	N-ammonium	9-16	(2.0)
	N-nitrite	9-12	(0.02)
Don and basin rivers	N-ammonium	9-16	(2.0)
	N-nitrite	9-12	(0.02)
	Phenols	100	
River of Krasnodar region (including Kuban)	N-nitrite	9-12	(0.02)
	Hydrocarbons	12	(0.05)

A few comments are in order about the Neva River and Lake Baikal.

1. Neva Inlet

The water quality in 1989-1990 remained unfavorable as a result of the construction of a large dam. The average concentrations of micro-organisms have reached 100 times previous concentrations, and the excess in the western sectors basin is sometimes 100,000 times.

The worst situation is found behind the southern wing of the dam as a result of slow water circulation, as well as in the discharge areas from the municipal water purification facilities of the city of Petersburg. The uncovering of the water circulation hole in the southern wing of the dam was not sufficient and effective enough. Additional water circulation and flushing is clearly required.

2. Lake Baikal

The ecological health of Lake Baikal cannot be characterized as satisfactory. The pollution zone in the area of the Baikal pulp and paper mill remains at the former level. Strong phytoplankton blooms are observed in the southern end of the lake. The waste water discharge carries 26,523 tonnes/year of inorganic salts and 189 tonnes/year of suspended substances into Lake Baikal.

The discharges of sulphates into the lake have decreased by 5% as compared to the previous year, but at the same time the discharges of organic and sulfo-organic and sulphur-organic substances have increased by 24% and 48% respectively.

TABLE II

Sea Water Pollution in 1990.

Region	Number of cases of HP level
CARA SEA including OB river	36
CASPIAN SEA including VOLGA river	23
AZOV SEA including DON RIVER	12
BLACK SEA	11
BALTIC SEA	3
BARENTS SEA	4

Toxic Pollutants in the Russian Seas

1. Oil Hydrocarbons (OH; MPC - 0.05 mg/1)

In 1990, the average level of pollution of open waters from oil hydrocarbons (OHs) did not exceed MPC, except in the Azov Sea. Among the coastal regions most polluted by OHs are:

-Gulf of Taganrog (2 MPC);
-coastline of the Don River delta (3 MPC);
-the Strait of Kerch (2 MPC);
-Mariupol Harbor (2 MPC);
-Northeastern section of the Caspian Sea (2 MPC);
-coastal water of Ural River (43 MPC);
-coastal waters of the Caspian Sea (2-7 MPC).

2. Detergents (Ds)

The level of pollution by Ds (MPC for anion active Ds is 0.5 mg/L) in 1990 was below 1 MPC except in the Azov Sea (Mariupol Harbor ~1.2 MPC).

3. Phenols (Ps)

Average contents of Ps exceeded 3 MPC in the Azov Sea at the open cast colliery located in the middle Caspian Sea (6MPC); -northern Caspian Sea (3-4 MPC)-Dagestan shore (4-6 MPC).

4. Ammonia Nitrogen (AN)

AN was recorded in the Azov Sea at the Don River delta (1.1 MPC); at Temryuk (1.5 MPC); and in the coastal waters of Kuban River (1.5 MPC).

5. Metals (M)

(MPC of copper -1.0, cadmium -0.01, lead -0.03, mercury - 0.0005, manganese -0.01 mg/L).

Increase of M concentrations have been registered in the Baltic Sea:
in Neva River Inlet (copper - 5 MPC, manganese - 2 MPC);
at Petersburg Harbor (copper - 6 MPC, manganese - 2 MPC);
in the shallow waters of eastern part of Gulf of Finland (copper, Cadmium 2 MPC, lead -2 MPC, mercury 1 MPC).

6. Organochlorine Pesticides (OCPs)

OCPs have been detected practically everywhere. Their high concentrations have been registered in the Baltic Sea at the coast near Petersburg (DDT 80; HCCH up to 38 ng/L).

In the Azov Sea, OPCs have been detected in random samples (up to 2-13 ng/L). In the White Sea HCCH has been measured at levels of 1-2 ng/L). In the Caspian Sea HCCHs were detected in the northern Caspian Sea where DDT concentrations have increased from 19 to 21 ng/L in the bottom layer, as well as in the coastal waters of the Ural River.

It should also be noted that in 1989, aircraft observations revealed that some areas of the Artic sea were characterized by high densities of rafts of lumber, and oil plumes.

7. Radioactive Materials (RMs)

As is known, RMs are used in many applications in medicine, industry and research organizations. Other important sources include uranium mining, nuclear power stations, and plants for reprocessing radioactive substances. When in high concentrations, radiation is harmful to living animals and plants. Low concentrations of radioactive materials in water can also be harmful since they are accumulated in body tissues until damaging concentrations are reached. This is most serious for materials with long half-lives such as Strontium-90 and Cesium-137 with half-lives of 28 and 27 years, respectively. After the Chernobyl accident, radioactive fall-out, Cs-137 and Cs-134 have been detected in high concentrations in the Black Sea.

There are four main sources of radioactivity entering the Black Sea:

1. Danube River,
2. Dnepr River
3. Atmospheric fall-out; and
4. Supply of RMs from the shoreline as a result of precipitation and Spring Flood.

Before the accident on 26 April 1986, the level of Cs-137 was 15-17 decay m^3/s. Hypoxia and Anoxia (complete absence of oxygen) were detected in the bottom layers of the western part of the Gulf of Finland, Petersburg Harbor, and in the bottom layers of the central and south-eastern parts of the Sea of Azov. In the latter case, 0.93-3.12 mg/L of hydrogen were recorded.

8. Coastal waters and euthrophication

As is well known, coastal waters, particularly shallow seas, are highly affected by eutrophication processes which may result in hypoxia or in extreme cases, anoxia. Several important examples of eutrophication include the coastal waters of the Black Sea, Sea of Azov and the Caspian Sea. In these cases, eutrophication is a result of river discharges which are highly contaminated with industrial wastes.

The fisheries of the Azov Sea have declined dramatically as a result of eutrophication. In 1988, for example, the total amount of sewage effluent released into the Black Sea was 848 million cubic meters. The Danube River estuary alone received 262 million cubic meters of effluent (92% of which was untreated). Sewage effluent released into the Black Sea during 1988 contained 2,800 tonnes of nitrogen and 700 tonnes of phosphorus. As is well known, eutrophication plays a major role in decomposition processes leading to hypoxia. Similar situations have been observed in the Azov Sea and the Caspian Sea. In the former, low oxygen levels were found practically everywhere in summer.

In my opinion, eutrophication and toxic pollution of these systems should be considered as the greatest aquatic problems of Russia. Without solving the problems of toxic pollution, hypoxia and anoxia, it is impossible to save these aquatic ecosystems from permanent damage.

In my preliminary manuscript sent to the workshop committee, I briefly described some physical oceanographic theoretical and experimental approaches suited to the investigation of contamination transport processes in the sea.

Some features of coastal ocean zones

It should be emphasized that coastal waters have some pecularities which must be taken into consideration when one attempts to understand harmful processes.

1. Coastal zones often differ in physical properties from those of the open sea, particularly in the structure of ocean currents. As is well known, near-shore there can be isolated eddies which will dramatically decrease exchange between the open sea and coastal waters.

Pollutants which are discharged into such coastal waters will maintain high concentration levels for a long time.

2. Meteorological conditions including wind and solar heating. Hypoxia or low dissolved oxygen levels in water tend to be found during warming periods when increasing isolation stimulates photosynthesis. Moreover, solar heating also leads to an increase in density stratification , which, in turn, leads to reduced oxygenation of bottom waters, and a reduction by photosynthetic processes near the bottom.

Water diversions

Massive water diversion projects completed during the last two decades propagated a chain of events that have severely affected the natural hydrological balance of three major inland seas (Black Sea, Azov Sea, and Caspian Sea). Drastic reductions in river discharge resulted. In 1990, these reductions were:

Volga (11%)
Don (31%)
Kuban (47%)
Ural (31%)

Decreased river discharge into the Sea of Azov was responsible for a marked increase in salinity by 0.3 psu, and the collapse of its fisheries. A decline of anadromous fish and a 60% loss in primary production were noted.

The construction of eight dams on the Dnieper and Dniester Rivers caused similar results on the northwestern Black Sea shore; an area that once provided optimal conditions for the commercially valuable and unique species of fish (such as sturgeon and salmon).

Because of water diversion projects, e.g. eight dams on the Volga River, and three on the Kama River, the Caspian Sea (which once supplied 35% of the inland harvest of finfish, and 90% of the world's sturgeon), has lost 70% of its production.

To solve these problems, and to mitigate their impacts, it is necessary to create much better management strategies. In this connection, it would be useful to focus on means to reduce water diversion and to improving drinking water to the population, without causing detrimental changes in the aquatic ecosystems.

New studies of the Colorado and the Columbia River systems may be instructive.

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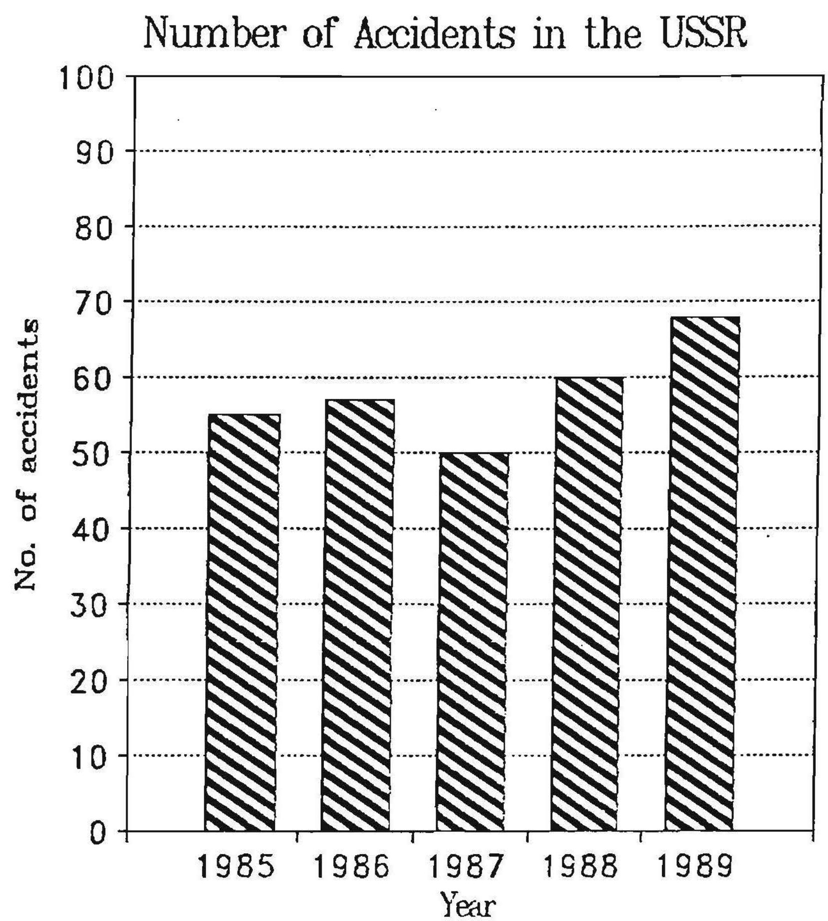
Number of Accidents in the USSR
100
90
80
70
60
50
40
30
20
10
0
No. of accidents
1985
1986
1987
1988
1989
Year

Figure 1a

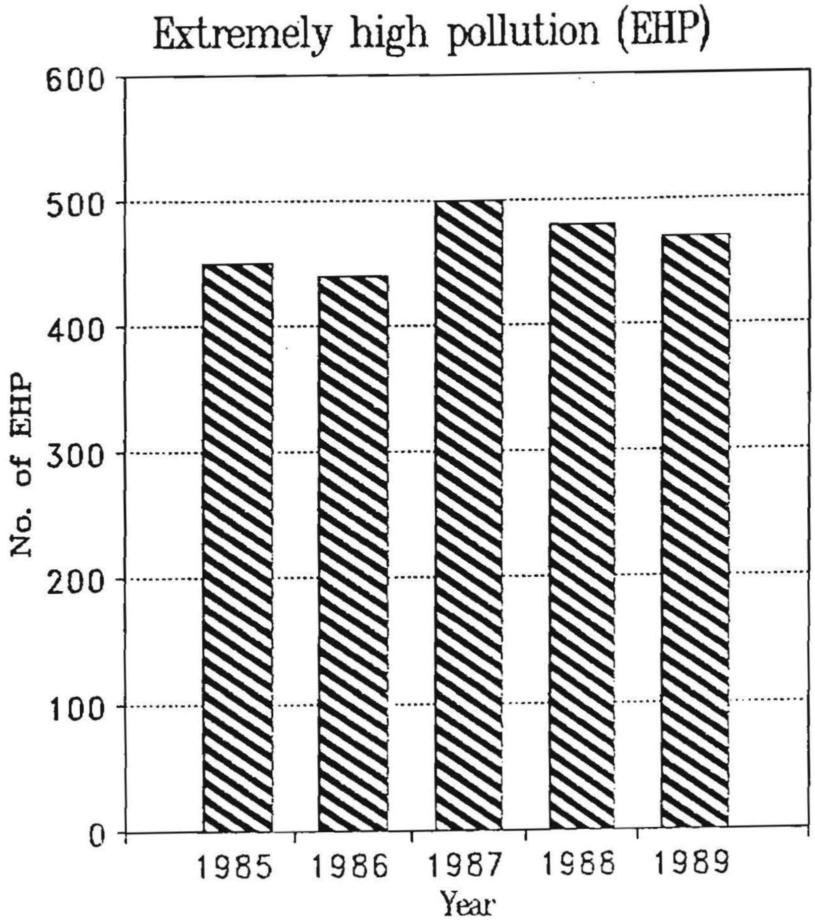
Extremely high pollution (EHP)
No. of EHP
600
500
400
300
200
100
0
1985
1986
1987
1988
1989
Year

Figure 1b

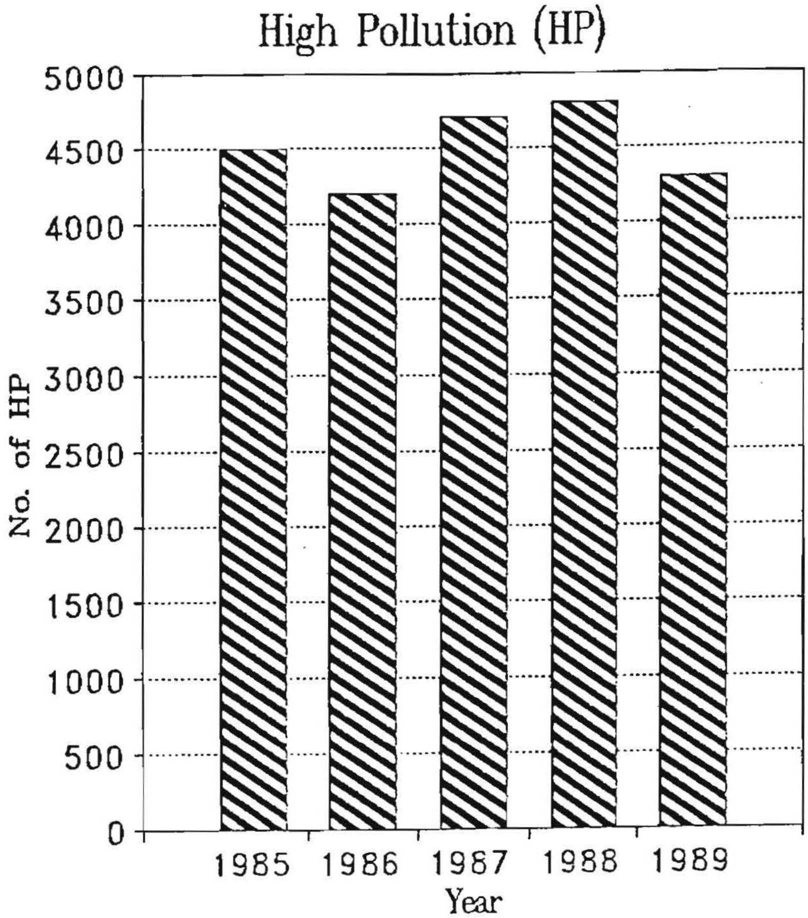
High Pollution (HP)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
No. of HP
1985
1986
1987
1988
1989
Year

Figure 1c

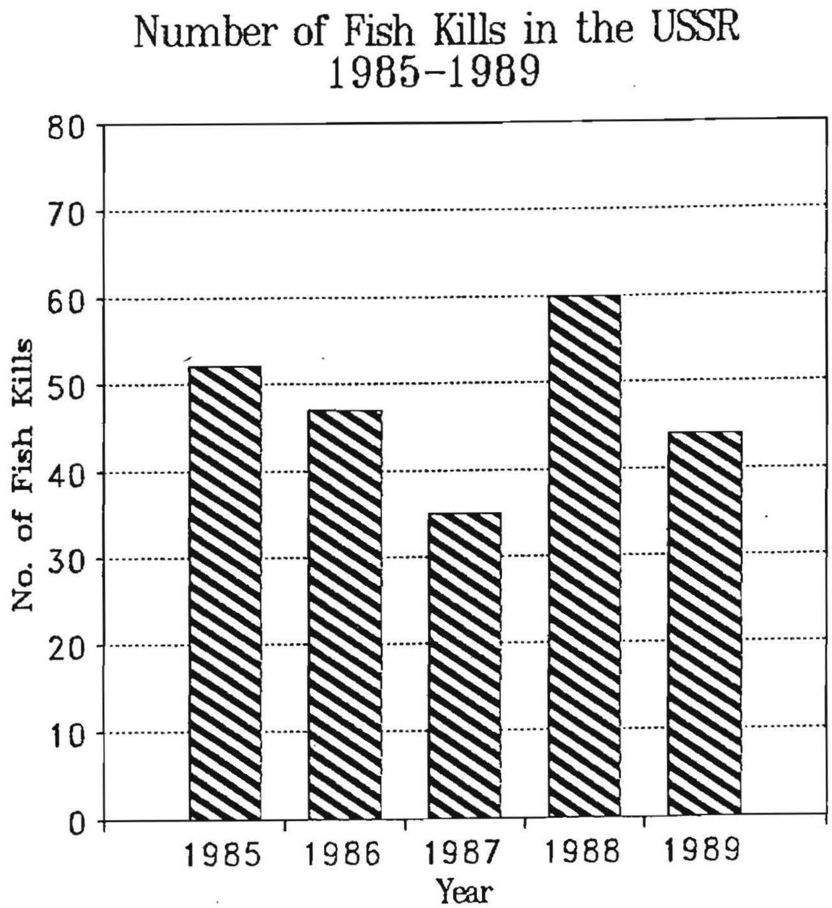
Number of Fish Kills in the USSR
1985-1989
No. of Fish Kills
0
10
20
30
40
50
60
70
80
1985
1986
1987
1988
1989
Year

Figure 1d

AQUATIC ENVIRONMENTAL PROBLEMS IN HUNGARY

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Introduction

Hungary is situated in the middle section of the Danube river basin. Being a typical agricultural country, the demand for irrigation water is high, and in general, the water management situation is unfavorable by European standards.

Hungary's total water resources are about 120 km^3/ year; about 50 percent of this amount is due to precipitation. Ninety-four percent of the surface water resources arrives from abroad through the national boundaries which are formed by rivers over a length of 600 km, as well as being crossed by 90 water courses of different sizes. This means that the availability and the quality of this water resource is determined to a large extent by the neighboring upstream countries. Observing the equitable and recognized demands, a considerable portion of the entering flow is released to downstream countries.

The amount of unevenly distributed water resources available in Hungary is about 20 km^3/year, 67 percent of this amount is supplied by surface waters and 33 percent by subsurface waters. Recently, about 20 percent of the available water resources was actually used for different water supplies, i.e., domestic, industrial, irrigation, fisheries , and recreational purposes.

Water quality and pollution problems

A great deal of effort has been made to satisfy the quality requirements of the different water uses, including the protection of aquatic ecosystem. Monitoring and research on both surface and subsurface waters, on water and wastewater treatment technologies, as well as legislative actions and international cooperations are enforced to be able to cope with the environmental pollution problems.

Giving a detailed account on these problems is not the purpose of this paper, however. Reference is made to the "State of the Hungarian Environment" report, published in 1990, which includes all relevant data and information, and it is attached to this report.

The major problem areas are as follows:

SURFACE WATERS

- "Imported" pollution
- Chronic discharges (domestic, industrial)
- Accidental pollutions
- Water quality problems at intakes for water supplies
- Euthrophication in lakes

SUBSURFACE WATERS

Bankfiltered waters
- River effects (micropollutants, etc.)
- Background effect (point and non-point sources)

Groundwater
- Agricultural effects, e.g., nitrates, (point and non-point sources)
- Hazardous waste disposal sites, e.g., legal and illegal, restricted areas, military (Soviet) zones

Deep aquifers
- Karst waters
- Confined groundwater, e.g. artesian

Priorities for Future Work

1. Formation of an integrated environmental monitoring and information system to ensure collection and dissemination of all data necessary for decision making regarding environmental protection/rehabilitation activities.

- Upgrading the water quality monitoring system for aquatic ecosystems and subsurface aquifers to include organic and inorganic micropollutants, and biomonitoring, e.g., species composition.

- Establishment of automatic water quality monitoring/sampling stations at the most important "hot-spot" river sections, particularly in the boundary rivers or in those crossing international borders, where high fluctuation in the water quality has been observed, as well as at downstream of major pollution sources.

- Setting-up and monitoring the inventory of pollution sources, e.g., from point and non-point sources affecting the aquatic environment.

- Development of a network to monitor the long-term effects of the Chernobyl catastrophe (Cs-137 mapping), and the establishment of an early warning system for monitoring radiactive radiation in the air and surface waters.

2. Carrying out environmental impact studies, assessment and audits in selected areas, regions, specific river basins,

covering the surface and subsurface water resources.

- Study of the effect of leaching pollutants from legal and illegal unsecured solid, semi-solid hazardous waste disposals on the groundwater and/or deep subsurface water resources. In this regard, particular attention should be paid in the areas where the detrimental effect to the groundwater aquifer is obvious. Environmental audit of the previously restricted industrial areas, abandoned Soviet military bases are of primary concern.

- Study of the effect of dams on the pathways of pollutants with particular attention to the planned Gabcikovo-Bos-Nagymaros dam system in the Slovakian-Hungarian Danube stretch.

3. Carrying out research, case studies on fate and effect of pollutants in the aquatic environment which might provide sound scientific basis for proper decision making and pollution control in the aquatic environment.

- Study of the pollutant accumulation and remobilization in river sediment emphasizing the possible infiltration of toxic pollutants into the bankfiltered water which is an important water resource for water supplies.

4. Development and adoption of state-of-the-art sampling and analytical methodologies, as well as experimental set-up, and implementing strict quality assurance program to ensure reliability and comparability of measurement results.

5. Enforcing development projects to ensure the optimal utilization of aquatic systems and the maintenance of the ecological balance.

Groundwater Pollution in Czechoslovakia and Some Problems of Groundwater Protection

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Czechoslovakia

Current situation

In the Czech Republic, groundwater is consumed as drinking water in 45 percent of public water supplies; another 1 to 1.5 million people use groundwater extracted from household wells. The mechanism of pollution and its development over time is different and delayed for groundwater in comparison with surface water. Moreover, it frequently remains concealed. Not only groundwater becomes contaminated, but also the saturated and unsaturated zones of rock. Cases of groundwater pollution were often dealt with in an isolated manner rather than embracing overall regional influences and interconnections. Also, effective quality control is lacking for hydrogeological systems. With respect to regional pollution sources, legislation is inadequate.

The situation is similar in Slovakia but there groundwater accounts for more than half of all drinking water supplies.

In Czechoslovakia, the most frequently occurring and environmentally harmful are point pollution sources, accidental leakages of oil and chlorinated hydrocarbons, and a broad range of chemicals, often toxic, which leak from hazardous waste dumps. Among the regional sources of contamination, the predominant causes are nitrate pollution in shallow and vulnerable aquifers in areas under intensive farming activities, and changes in the quality of atmospheric precipitation due to industrial emissions.

The usual methodology for cleaning up oil contamination is insulation of the focal point of the pollution and gradual decontamination of the groundwater found around it. Since the mid 1960s, hydraulic methods have most commonly been employed. They are technically simple and combine the insulating effect of the protective depression created, and a gradual, though somewhat slow, removal of contaminants from the rock medium by means of separation pumping using two pumps. As a principle, water is decontaminated above-ground on site, with the help of the so called vapex or textile FIBROIL filters. At the closing stages of clean up, in situ biodegradation has been applied successfully: nutrients are injected into the aquifer, or sometimes special or selected local microorganisms are used.

The complexity of cleaning up volatile chlorinated hydrocarbons (solvents and diluents) is caused by their high specific weight and good solubility in water (tenths to tens of grams per litre). An aquifer may be contaminated with these chemicals throughout its entire thickness. Clean and contaminated waters cannot be separated in clean-up boreholes during pumping and therefore all of the pumped water must be treated, which is a technically challenging and cost intensive process. For these reasons in situ decontamination is being introduced. Modern equipment is needed for this purpose rather than the know how. For example, there are no economical powerful vacuum pumps for the advanced method of volatile organics evaporation. Ventiliation of the vadose zone through a system of small-diameter boreholes is also used. A novel concept is stripping in the so-called self-cleaning boreholes when decontamination efficiency of more than 80 % can be achieved while all of the cleaning equipment is tempered naturally because it is placed directly in the pumped borehole, with the exception of activated carbon filters for cleaning used air. A powerful separator, so far unavailable in Czechoslovakia, would render the process of pneumatic methods more effective thanks to recuperation of solvents.

Technically more complicated is the cleaning up of polychlorbiphenyls (PCBs). There are numerous locations in Czechoslovakia with potential sources of groundwater contamination by DELOR. This chemical contains high levels of PCBs. Until January 1984, DELOR had been commonly used as a heat-transmitting medium in factories where gravel was coated for road building, as an insulating medium in transformers and capacitors, and as a plastifier in varnishes and paints. The last mentioned source in recent years caused a serious problem with PCB contamination of cow milk, butter and meat (in southern Moravia and central Bohemia); silage troughs and indoor spaces of cowsheds had been painted with this material. Unless DELOR sources are safely liquidated or "buried", their penetration of the rock medium and water can be expected (between 1959 and 1984, 19,674 tonnes of DELOR were produced in Czechoslovakia). Concentrations of 14 g/kg of PCB in the soil sampled near the Zatec water supply plant are alarming. So far, we have not mastered the in situ decontamination of rocks; no incinerating plant exists for such materials, and no controlled toxic waste dump has been allocated for this purpose. We are still relying on hydraulic methods for the removal of PCBs. Pumped water must be cleaned in activiated carbon filters. This method is expensive and impractical because of the absence of activated carbon recuperation technology. The problem can only be solved by importing soon the equipment for rinsing and incinerating chlorinated hydrocarbons, and/or equipment for groundwater decontamination by way of ozonization combined with UV radiation.

Another predicament for aquifers are wastes. According to qualified estimates, about 75% of hazardous and toxic wastes produced in this country are stored unsuitably ,thereby creating potential sources of environmental pollution.

Regional nitrate contamination of groundwater is observed in Czechoslovakia in areas under intensive, especially field, farming. There are impacts on the quality of shallow vulnerable aquifers situated in Quaternary and Tertiary sediments. In the Czech Republic, there are potential threats to phreatic aquifers found in sandstone and marlite structures of the Czech Cretaceous Basin. The intensification and specialization of agricultural production in our Republic over the past thirty years has resulted, among other things, in a substantial increase in the amount of fertilizer used. Fertilizer usage has shot up eight to ninefold on the average, while crop yields have only doubled, and nitrate contents in groundwater have doubled or tripled in the same period.

TABLE 1

Changes in nitrate contents in water supply plants of the Middle Elbe region:

Year	1968	1970	1975	1980	1985	1990
# of plants	33	38	66	71	78	71
Share in %	9.1	10.5	12.1	26.8	17.9	35
Average conc. (mg/L)	20.7	23.1	28.7	35.2	28.7	32.7

"Share in %" stands for the percentage of water supply plants with nitrate concentrations over 50 mg/L, i.e. above the drinking water standards. The highest level detected was 121 mg/L of nitrates. However, in certain areas of southern Moravia nitrate levels in shallow wells are as high as 400 to 500 mg/L.

Research into the impacts of farming on groundwater has revealed in particular:

- long term liability to nitrate increases in shallow aquifers found in fluvial deposits;

- short term cyclic changes in nitrate contents, especially in the upper parts of shallow aquifer

- rapid response of the hydrogeological system to extreme climatic situations;

- vertical hydrochemical stratification and heterogeneity of

shallow aquifers (substantially more nitrates in their upper parts);
- distinctive effect of soil on groundwater quality, and

- vertical movement of contaminants in the unsaturated zone at a rate of 0.1 to 0.4 m/year.

Protection here translates into prevention: choice of different procedures, timing and manner of fertilizer application, and, in particular, their kinds and amounts. In situ nitrate decontamination is more important in terms of water treatment than in terms of targeted rehabilitation of shallow aquifers.

Since last year, the quality of water and bottom sediments has been monitored in cooperation with Germany, from Elbe sources in the Krkonose Mountains downstream to its estuary in Hamburg: the major load, in addition to nitrates, are metals and organic micropollutants.

<u>Problems of groundwater protection in the near future</u>

The political and economic changes triggered by November 1989 have had a strong effect on environmental questions, including those of groundwater protection. The phasing out of research programs for the detection and decontamination of polluted aquifers has been offset by the opening of borders to both information from, as well as straightforward collaboration with, western institutions and companies. However, there are limits in terms of financing. Two new problems have emerged for Czechoslovakia:

1. Complete decontamination of the structures underlying former gas supply plants, fuel storages and other environmentally dangerous operations in the context of privatization; and

2. Investigation and clean-up of contamination of the former Soviet military bases. There were 80-plus of them in this country, and some of them were located in zones of hygienic protection of groundwater.

The specifics of investigating contamination and clean-up at Soviet bases arise from the long-term inaccessibility to the sites where various kinds of contaminants had been stored and used, the result being a considerable level of contamination of the hydrogeological system and occurrence of different, scattered sources of pollution such as uncontrolled, moreover masked, dumps. Apart from aviation fuel, oil and petrol, the areas formerly occupied by the Soviet Army often offer an abundance of trichlorethylene, dichlorethylene, and the presence of anti-freezing agents, chemicals for combat training and DDT cannot be ruled out. The rock medium is contaminated over several tens of square kilometers, and the volume of contaminated rock skyrockets to millions of cubic meters.

We regard the Milovice Soviet military base east of Prague as the most dangerous such site; captation of drinking water for Prague is threatened by oil and chlorinated hydrocarbons there. The military airfield at Hradcany near Mimon, northern Bohemia, features important water resources in sandstones saturated with hundreds of thousands of liters of aviation fuel. The oil layer that rests on the water table is 1 to 400 cm thick. In 1991 alone, some 150,000 liters of fuel was pumped out from underground.

In Moravia, Soviet units contaminated Quaternary gravels near Olomouc, which serve as water sources.

In Slovakia, important drinking water resources face danger at Nemcova, as do the waters in the protective zone of the Sliac spa resort. Between 1981 and June 1991, 321 m^3 of oils was pumped out of the local aquifer.

Under particularly difficult geological and technical conditions, the investigation and clean-up of extensive contamination will obviously not be done without foreign help. Apart from the feasibility well for investigating toxic wastes in Chabarovice, northern Bohemia, TDP prepares cooperation on the Milovice site: the use of remote sensing and penetrating radar methods for detecting hazardous wastes.

The costs of investigating clean-up are being estimated at many billion Czechoslovak crowns. Talks on hydrogeological exploration with Soviet experts are currently underway.

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