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PILOT ZONES FOR WATER QUALITY MANAGEMENT

Report on a Seminar

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Note

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1. INTRODUCTION

As part of the completed UNDP/WHO-assisted project "Pilot Zones for Water Quality Management" (HUN/71/505 - HUN/PIP 001), the Regional Office for Europe of the World Health Organization held a seminar in Budapest from 30 November to 2 December 1977, in collaboration with the Government of Hungary.

The seminar was designed to bring together experts, mainly from countries riparian to the river Danube, to review and discuss both the techniques and practical aspects of water quality monitoring and water quality modelling employed on the project. The results gained in these subjects during the five years' life of the project (1972-76) were carefully examined to see whether they might form a basis for formulating a future intercountry cooperative programme to investigate the quality of water in the river Danube and its tributaries. It was felt that the deliberations of the seminar could help significantly in recommending the best way in which the quality of water in the Danube could be safeguarded, particularly as many of the problems of the Danube needed investigation over the basin as a whole.

The seminar was attended by 71 participants from eight countries and by representatives of the Danube Commission, the Economic Commission for Europe of the United Nations (Environment and Human Settlements Division), the International Institute for Applied Systems Analysis, the International Limnology Society, the United Nations Development Programme, the United Nations Environment Programme, and the WHO Regional Office for Europe (a complete list of participants is given in Annex III).

Seven general reports and 22 discussion papers presented by Hungarian experts, covered all aspects of the work of the project (see section 2). In addition, the two WHO temporary advisers presented papers on the optimization of water quality monitoring networks and on sediment transport and deposition.

One section of the programme was devoted to hearing statements from the experts of the six riparian countries present (see section 3.1), dealing principally with the work being carried out in each country on Danube water quality problems. Statements were also made by participants from organizations in attendance (see section 3.2).

Dr G. Illés, Vice-President of the Hungarian National Water Authority, welcoming participants, described the two pilot zones that had been established under the UNDP/WHO-assisted project, one on the Danube upstream of Budapest, and another on the Sajó River, which was both used as a water supply and a channel for the disposal of effluent by the industries within its catchment area. Water quality problems had increased rapidly during recent decades in the two zones.

The objective of the project had been to provide answers to problems and practical guidance for the abatement or prevention of water pollution, the consequences of which had imposed an increasingly serious burden on the Hungarian economy.

International experts visiting Hungary had provided considerable help in the shape of guidance and advice. Perhaps just as important had been the fact that more than 130 Hungarian specialists in the engineering, legal and economic problems associated with water quality and pollution control had been given the opportunity to expand their knowledge through study tours to countries with advanced water quality management systems. Dr Illés stressed that the instruments purchased with project funds had assisted greatly in modernizing the equipment of the laboratories.

He expected that by utilizing the results of the project and the seminar, and by integrating the efforts of the water authorities and other official agencies in the Danube countries, progress would be made in solving the often serious water quality problems of the basin.

Dr Leo A. Kaprio, WHO Regional Director for Europe, reviewing the purpose of the seminar, also stressed that the project implementation had confirmed that international cooperation in the field of water quality protection, especially for Hungary, was vital and necessary. As Hungary derived 96% of its water resources from other countries, the Hungarian authorities gave high priority to future international cooperation over the Danube's water quality.

Though the river was not at present as polluted as some other European rivers, the expected rapid economic development along the middle and lower reaches of the river following the opening of the Rhine-Main-Danube canal in the nineteen-eighties would, unless suitable effective water quality management plans were made, cause a further degradation in quality of the river waters.

There had already been a preliminary exchange of views with interested governments and the relevant specialized agencies of the United Nations on possible cooperation in the assessment of the water quality of the river Danube. This seminar, which marked the formal closure of the UNDP/WHO-assisted project in Hungary on water quality management, might be considered an initial step in bringing together scientific and other institutions in all the riparian states so as to arrive at a common methodology for assessing the quality of water in the river Danube.

Dr R. Muts, Director of the Hungarian Institute for Water Management, stressed the value of the project and expressed the readiness of his institute to help in the water quality management effort by, for example, developing short-, medium- and long-term regional studies. It had a special interest in the water quality problems of rivers flowing through more than one country.

A statement by Dr G. Fekete, Director of the Danube Commission, is summarized under section 3.2 below, as is a speech by Mr S. Andersen, Assistant Administrator and Director of the European Office of UNDP.

Dr O. Starosolszky was elected Chairman of the seminar, Mr D.H. Newsome acted as Rapporteur and Mr I. Matrai as Co-rapporteur.

2. PILOT ZONES FOR WATER QUALITY MANAGEMENT IN HUNGARY

A total of seven general papers and 22 discussion documents were presented by Hungarian specialists during the seminar. In addition, two papers of invited foreign lecturers were presented and discussed.[1]

2.1 Research and development

2.1.1 Introduction (by Dr P. Benedek, Research Centre for Water Resources Development, VITUKI, Budapest)

Dr Benedek gave a synoptic view of the water resources in Hungary, explaining that 96% of its surface water originated in other countries and supplies of good quality groundwater available at reasonable cost had been exhausted. Additional supplies had therefore to be derived from surface water resources.

The Danube was the principal source of water; even the shortages occurring in the Tisza basin would be alleviated in the distant future by water transferred from the Danube.

At present, over almost its entire length the Danube was capable of assimilating the pollution load from its effluents discharged to it. On the Hungarian stretch of the river however, some determinands, especially bio-resistant substances, had already attained the limit beyond which wastewater treatment was necessary.

The relatively low level of sewerage facilities, the rapid development of industrialization, the shift to intensive farming in Hungary and further rapid development of urbanization meant that an increase in pollution was unavoidable unless strong counter-measures were taken. There was, therefore, a need to formulate pollution control strategies, in which legal regulations and economic incentives would play an important part, and to lay the foundations for employing advanced water quality management techniques.

The riparian countries were concerned to preserve unobstructed navigation in this international waterway but this could not be maintained without the construction of a series of barrages across the river. Such barrages could also be used for hydroelectric power generation to make a contribution towards meeting the demands for additional electrical energy of the riparian states.

While there had been cooperation between Hungary and its neighbours in CMEA, it was no longer enough and more extensive international cooperation was necessary if the Danube was to be restored to its one-time quality.

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[1] A summary of the reports and discussions is given here; the full texts are to be published by the Hungarian National Water Authority (a list of working documents is given at Annex II).

2.1.2 Discussion

(a) Comments by Dr Gy. Kovács (Hungarian National Water Authority, Budapest)

Dr Kovács agreed that due to rapid economic development in the last few decades, freshwater resources were no longer adequate to meet safely the ever-increasing demand for water. Rational control of the environment therefore included both the quantity and quality aspects of water management.

The environmental problems of water resources development had been summarized recently in a UNEP document as follows:

- the forecasting and control of future demands; analysis of and regulation of quantity and quality requirements;
- establishing an inventory of the quantity and quality of available water resources and the formulation of measures to both conserve the resources and improve their quality;
- quality control of soils, surface and groundwater including methods of wastewater treatment, localization of pollution problems and the slowing-up of eutrophication;
- the control of the secondary effects of large-scale water resources projects e.g. irrigation, storage, land and swamp reclamation and groundwater exploitation.

Dr Benedek had not only emphasized these points but also the close connexion between the three interrelated media, air, water and soil. The research and development of water quality control therefore required the use of multidisciplinary teams composed not only of scientists but people with experience of the practical problems too. To be successful, there must be continuity between pure and applied research, the development and practical application of the results obtained by such teams. The planning of research and development should therefore always start with the identification of the practical objectives to be achieved. The medium- and long-term research and development plans of water management in Hungary had been prepared on this basis.

Some research topics on the practical objectives included:

- the development of a uniform monitoring network for surface and groundwater;
- the derivation of guidelines for sampling methods, sample analysis and the development of a network of automatic monitors and new sensors for them;
- the establishment of emergency teams whose duties would include the protection of water against accidental pollution and the minimization of damage caused by such pollution incidents. (The development of suitable equipment and warning systems, the preparation of practical guidelines for their operation and the organization of the teams, were associated research and development topics.);
- water quality modelling for the prediction of water quality at certain river sections was particularly important;
- the standardization of wastewater treatment techniques, the development of standard prefabricated treatment plant and the automation of the operation of treatment plant;
- the disposal of sludge and other wastes;
- quality control of water in reservoirs;
- the protection of soil against salt accumulation by land drainage.

The UNDP/WHO-assisted project had enabled a start to be made on many of these topics and had proved to be an excellent basis for further development work.

(b) Comments by Dr F. Papp (Hungarian National Water Authority, Budapest)

The solutions outlined by Dr Benedek would not be easy to achieve, especially in Hungary where the national boundary was crossed by no less than 89 streams. Because streams both entered and left Hungarian territory, Hungarians were acutely aware of the harmful effects of polluted streams on downstream neighbours. Thus, the riparian countries were mutually interdependent not only in time of floods but throughout the year. In 1975 for example there had been nearly 20 accidents in the Danube catchment solely due to defects in oil pipelines, and the incidence of these was liable to increase in the future. Such occurrences underlined the need for closer cooperation between the riparian countries in protecting their environment and in particular the aquatic environment.

Dr Benedek had given the proper priorities to the demand for recreational activities in the Danube Bend and in the Rachéve Danube Arm, the nature conservation aspects of the Gemenc Forest, and the ecological impact of the proposed Gabcikovo-Nagymaros hydro-electric project.

It was important for the interrelationships between the three most important elements of the natural environment (soil, air and water) to be considered simultaneously, and for water quality management to be considered comprehensively from the atmosphere to groundwater and over the entire catchment. It was also essential for thorough comprehensive technical analyses to be conducted before embarking on any economic studies.

He did not agree that Hungary's groundwater resources had largely been exhausted. They should not be regarded as capable of yielding only a fixed quantity, because water management techniques were in existence which could increase the yield of aquifers, while still conserving the quality of the water they contained. It was for reasons such as this that the catchment area should be studied as a whole.

2.2 Data collection systems in water quality management

2.2.1 Introduction (by Mr G. Pinter, VITUKI, Budapest)

The main objectives of the data collection carried out in the UNDP/WHO-assisted project had been to provide the necessary information for operational, planning and research purposes, Mr Pinter said. The basis of the system was the use of data collected routinely by various water management authorities, but the frequency of collection and, in some cases, the actual sampling site had been changed to suit the needs of the project. This had come to be supplemented by the use of intensive surveys of water quality of comparatively short duration (two to seven days) and the installation of automatic water quality monitors at certain sites which recorded data on an hourly basis.

Describing the data processing, storage and retrieval system, and the data base created for water quality modelling in the Sajó and Danube pilot zones, Mr Pinter concentrated on the practical experience gained during the course of the project, particularly the difficulties experienced in the operation of automatic water quality monitors.

The experience gained in the pilot zones had been used to extend and develop the existing water quality data collection system on the River Danube.

2.2.2 WHO Workshop on the optimization of water quality monitoring networks (by Mr D.H. Newsome, Water Data Unit, Reading, United Kingdom)

Mr Newsome recalled that the Workshop[1] had received descriptions of water quality monitoring policy and activity from all the participating national representatives, and also the international GEMS programme.

The objectives of water quality monitoring networks had been considered and classified into:

Organizational levels	:	Local, area, national, international
Management functions	:	Operations/control, planning/research, special activities
Operational state of the system	:	Routine, emergency

1 WHO REGIONAL OFFICE FOR EUROPE, The optimization of water quality monitoring networks, report on a workshop, Reading, 4-14 January 1977, Copenhagen, 1977

Each class had been examined and recommendations had been made regarding frequency and timeliness of reporting. Determinands of interest had been listed.

Guidelines had been set down for network design to meet particular objectives, covering, inter alia, sampling sites, sampling techniques, frequency of reporting and methods of analysis.

A subgroup had studied the structure of a water quality information system (clearly only one part of an overall water information system) and determined the structure and interconnexion of the main elements of such a system.

A general philosophy had been suggested for establishing and developing the information system which recommended that "area centres" be established first. Lower level "local centres" would be introduced as the need arose.

The group had also studied the range of data and information and facilities needed at each level in the general scheme.

Important conclusions of the Workshop had included:

(a) the need to define the objectives of water quality monitoring schemes;

(b) the need to design water quality networks within a policy for the development of an effective and comprehensive water data/information system, while recognizing the existence of political and other constraints; and

(c) the need to involve preliminary study and pilot operations in the process of developing water quality networks.

The Workshop had recommended that:

(a) an advisory group be established, with broad terms of reference;

(b) a thorough review be made of biological techniques in the measurement of water quality;

(c) studies be made of pollutants in biota and bed sediments; and

(d) the Workshop discussions be utilized in the establishment of the GEMS network, particularly in the WHO European Region.

2.2.3 Discussion

(a) Comments by Dr Zs. Deak (National Institute for Hygiene, Budapest)

Dr Deak described the results of a bacteriological survey of the River Danube between June 1973 and December 1976, analyzing 455 samples collected from 11 sites between Rajka and Budapest, with the goal of determining the extent and variation of faecal and non-faecal pollution and their effect on water use. The analysis included the determination of faecal and non-faecal indicator bacteria and, to obtain some epidemiological information from water quality, the analyses were extended to include the recovery of enteric pathogenic bacteria belonging to the salmonella group and to bacteriophages.

The survey indicated that at the beginning of the section at Rajka, the density of faecal and non-faecal bacteria was significant. Pathogenic bacteria were detected in all samples tested. Over the section, the river changed in character from a mountain to lowland-type river. It had a great assimilative capacity and the pollution as measured in terms of bacteriological parameters decreased substantially, but in wet years the count of *Clostridia* increased considerably due to the disturbance of bottom silts.

On average the counts of faecal indicator bacteria decreased by 70% between Rajka and Budapest, and others also decreased. Only the resistant spore-forming *Clostridia* showed no decrease. The incidence of *Salmonella* remained significant over the whole length of the section and during the survey 1,035 strains of *Salmonella* were isolated at the 11 sampling points. The highest rates, 390 per litre, were observed in the autumn. Typhoid and paratyphoid bacteria were also observed.

According to recommendations by WHO and the US Environmental Protection Agency, the critical water quality parameter for water contact recreation was the faecal coliform count, with a limit of 2/ml. The data collected showed that the faecal pollution of the Danube was 10-60 times higher than the recommended value. Similarly, the CMEA water quality criteria issued by the Council for Mutual Economic Assistance (CMEA) recommended that for water supply, recreation and irrigation, suitable surface waters are those where the coliform count is less than 100/ml and where no pathogens can be detected. Clearly, the polluted River Danube could not be recommended for water contact recreational purposes and as a consequence the costs of treatment of water for public supply are more costly too.

Under unusual conditions of high flow and in winter a considerable increase in the Clostridia count was observed close to the Budapest water supply intakes. The poor river water quality affected the quality of water put into supply in the metropolitan area and resulted in an objectionable Clostridia count. This indicated that resistant microorganisms like spore-forming Clostridia and bacteriophages can survive the water treatment and disinfection processes. This suggests the possibility that enteroviruses may also be able to get into the water supply.

Finally, a preliminary analysis of the bacteriological characteristics, stream flow and water temperature had revealed that the last two variables influenced the number, species survival and regrowth of the bacteria. It was also of interest to note that stormwater runoff changed the composition and density of the bacterial population.

(b) Comments by Dr P. Literáthy (VITUKI, Budapest)

Dr Literáthy said that five automatic water quality monitors had been established as part of the project: three on the Sajó, and two on the Danube. All were at important sites and their installation was therefore justified, even though they measured only the determinands monitored commonly elsewhere in the world. Temperature, pH, dissolved oxygen, conductivity and turbidity yielded inadequate information on certain kinds of pollution, but the evaluation of large volumes of the data produced by the automatic monitors revealed that they provided no better information than that obtained from the analysis of 52-104 manual samples per annum. It was therefore his view that automatic water quality monitors displayed a poor cost/benefit ratio.

Moreover, instruments designed specially for the measurement of certain specific pollutants, e.g. the measurement of ultraviolet absorption on 254 nm wavelength, the detection of petroleum pollution by the fluorescence principle and the measurement of the dissolved iron content had been tried but, due to operational problems, all had failed to live up to expectations.

It was therefore thought to be not economically advisable to invest in additional automatic water quality monitoring stations before the required sensors had been developed. Thus the principal immediate task was that of sensor development.

Dr Literáthy quoted from the experience of ORSANCO in the USA and from Japan, where similar experience had been gained. It was interesting to note that in the Ohio basin, ORSANCO were installing miniature laboratories at ten gauging cross-sections where continuous samples would be analyzed by gas chromotography with great frequency.

In conclusion, the installation of numbers of automatic water quality monitoring stations should be avoided, but those built at key points should be capable of monitoring the typical pollutants at those sites.

(c) Comments by Dr I. Hoffmann (VITUKI, Budapest)

Dr Hoffmann described the steady improvements in the instrumentation used by laboratories as a result of the project. Initially they had been able to perform the classical routine analyses only. With the installation of advanced apparatus, such as apparatus to determine TOC and TOD, an atomic absorption spectrophotometer and a gas chromatograph, they could now carry out the most advanced analyses and detect most pollutants. There had been three phases in upgrading the instrumentation: training Hungarian specialists in the use of the instruments, commissioning the instruments and finally putting them into operation.

(d) Comments by Dr B. Csermák (Water Management Institute, Budapest)

Dr Csermák was impressed at the progress made both in this field and in data processing during the past few decades. He pointed to the remarkable similarity between the concepts and methods used by experts in assessing the quantity of the available water resources and those now being used by experts assessing the quality of the resources.

Until the mid-sixties in Hungary, data had been collected in a random and non-uniform manner by different bodies, so that comparisons had been impossible. In the mid-sixties, however, the National Water Authority had adopted CMEA recommendations which had led to the progressive harmonization of data determination and measurement, collection and storage. The project had accelerated this process. The standardization of data collection and processing was an essential step in identifying the minimum amount of data needed in order to satisfy demands for information and to answer all questions. Nevertheless even after almost a decade of the implementation of standards, there were still occasions where, at the boundaries between operational areas of two regional water authorities, anomalous results emerged.

The Institute of Water Management was also beginning to accumulate data on the demand for water and the volume of wastewaters, but some time would elapse before there was a bank of time-series data that would be useful on a district or national scale.

Finally, models constructed to support practical engineering problems were of little use if the data fed into them were not reliable; data quality control was therefore very important.

(e) Comments by Mr K. Almás (Water Management Institute, Budapest)

Mr Almás said that under the project, computerized data processing had been introduced in 1974 to aid the study of surface water pollution. Data were mainly collected from the standard observation network of stations in Hungary but to serve the more sophisticated objectives of the project additional data were collected from sites in the pilot zones. Most of the programmes used were standard programmes for processing surface water data, but some additional programmes had been written specially to meet the needs of the project.

He classified them under the following headings:

- processing data on the quality of surface waters,
- processing monitored data recorded at hourly intervals,
- processing the records of regional centres collecting monitor data,
- processing data on micro-pollutants, and
- printout of data on pollution sources.

Statistical analyses could be carried out on all the data.

(f) General discussion

In reply, Dr Benedek said that research was only useful if the results were implemented in practice. The establishment of VITUKI as the research and development centre and the close cooperation that had developed between it and the Institute of Water Management, in association with the various field agencies, meant that research results would be widely disseminated and put to practical use.

The available groundwater resources had been reassessed in the past two years and he agreed with Dr Papp that there was still some potential for development.

2.3 Engineering/economic models

2.3.1 Introduction by Dr G. Bora (Karl Marx University of Economics, Budapest)

Dr Bora said that one of the basic aims of the UNDP/WHO-assisted project had been to construct an engineering/economic model of the Sajo River basin which would contain all the most important aspects of water management. It would take into account the hydrological, technical, economic and social aspects of water quality management.

He outlined the concepts behind the model's formulation, its requirements for data, the variables included, and the results obtained. He recommended that, in future extensions to the model, there should be an investigation into the reduction of water consumption by industry in which the technological and cost implications would be weighed against the resulting economic and environmental benefits. Water recycling costs would be compared against the costs of abstraction and treatment plus the cost of wastewater treatment.

2.3.2 Discussion

(a) Comments by Dr G. Mucsy (VITUKI, Budapest)

In his contribution Dr Mucsy argued that the basic information necessary was a thorough knowledge of the sources of pollution in the catchment and an inventory of the major ones. Information needed included the technology of production, the materials used, and data on water use by factories and other industrial activities including the nature and volume of wastes and the method and efficiency of any treatment they received. Difficulties were naturally to be experienced in large industrial complexes, but the most effective way of tackling complex problems was to involve the professional staff of the industrial undertaking to assist in the work.

Secondly, it was important to gain some knowledge of the development plans for the factory and the likely effects that these would have on the nature and volume of effluent produced. The same was true for the development of new industry, with the additional need to consider the increase in population that would occur as a result of the industrial development. From this information the effect of these developments on the receiving waters had to be predicted, e.g. variations in streamflow and water quality characteristics.

Recommendations had then to be formulated on the appropriate treatment to give each effluent, so that water resources could be used as economically as possible.

Recycling of water was of great importance because it reduced the volume of freshwater needed as well as reducing the volume of effluent produced. Frequently it also brought about radical operational changes in the production process at a given factory.

It was important to test several alternatives for both engineering and economic feasibility before any decisions were made. Even the volume and programme of production should be considered and the relevant changes suggested.

In the Sajó pilot zone, 17 major sources of pollution had been identified, and 53 alternative combinations of wastewater treatment methods had been considered for them which were used in the optimization process. Once the data for the large number of alternatives were available, together with the basic conditions of the receiving waters, the model could be formulated, put on a computer and programmed to produce a solution which would result in the desired water quality in the river at least in terms of costs of construction, operation and maintenance.

(b) Comments by Dr G. Reczey (Karl Marx University of Economics, Budapest)

Dr Reczey was concerned with obtaining cost data from which he could predict the capital and operating costs of sewage treatment plants with different qualities of effluent at various points on the river. It was not too difficult to construct the capital and operating cost functions correlated to the technical parameters for proposed plants, because they were based on data from existing plants, provided by several agencies, but principally by VITUKI and MELYEPTERV (The Planning Institute for Civil Engineering).

Dr Reczey concluded by giving examples of the cost function equations that had been derived and discussed their advantages and drawbacks.

(c) Comments by Mr J. Pinter (Karl Marx University of Economics, Budapest)

The basic aim of the engineering/economic model for the Sajó region was to optimize the capital and operating costs of water pollution control while meeting the stipulated technical and economic requirements. The constraints in the model were based on the mixing and self-purification characteristics of the receiving waters, Mr Pinter said.

Several alternative treatment facilities were considered for each source of pollution, along with their associated cost implications.

After some trial runs, the model was successfully formulated and run and a scheduling model for optimizing the planned development programme was also constructed using integer programming methods.

(d) General discussion

The philosophy of use of automatic water quality monitoring was questioned. It was thought that too much was expected from them in terms of accuracy and the view was expressed that it was relative measurement that was needed: it was the change in value that was critical. If that was accepted, the need for accuracy was not so important and many sensors, particularly selective ion electrodes which had previously failed on the grounds that these were insufficiently accurate, would be worth re-examining in the light of the philosophy explained. If that fact was recognized, measurements could be made of pollutants that were of real interest rather than the ones which could be measured at the moment.

Use of the present automatic water quality monitors was defended and examples given of how they had detected pollutants which would probably have been missed by other sampling methods.

It was conceded that automatic water quality monitors had a role to play, but they were still of limited use. Careful thought should therefore be given before the installation of one was recommended. In particular, the cost/benefit ratio should be considered.

2.4 Descriptive dispersion model for the River Danube

2.4.1 Introduction (by Dr L. Somlyody (VITUKI, Budapest)

In the Danube, because the level of pollution was low and the transverse changes were predominant, and the impact of planned barrages was unclear, a conventional one-dimensional model was no use. A two-dimensional dispersion model had therefore been formulated as a first step towards the formulation of a two-dimensional water quality model.

The model, which was a steady state one, utilized depth integrated values written in a curvilinear co-ordinate system and the numerical solution was obtained by using the method of finite differences. Stability criteria were given and the model was tested.

The velocity distributions were obtained by field observations or by empirical relationships based on the observations. To determine the transverse dispersion coefficient, tracer measurements were performed which verified the Elder formula. The effect of bends was calculated approximately using the formula derived by Fischer.

Dr Somlyody said that an attempt had been made to make the model fit several hundred kilometres of river while relying only on routinely collected data, but it would be dependent on variations due to change in flow in the river. For this application, the flow had to be simulated using a one-dimensional hydraulic model.

The practical applications of the model were illustrated by three examples. The length of the longest reach successfully modelled was 59.4 km and the fair agreement between the values computed and those observed demonstrated the validity of the model formulated.

2.4.2 Discussion

(a) Comments by Dr Ö. Starosolszky (VITUKI, Budapest)

Dr Starosolszky said that a physical model capable of reproducing the mixing process was the only method of tracing the variations of the water quality in large rivers. Effluents discharged were frequently distinguishable from the general river water for many kilometres. The length of the "plume" depended on the flow conditions prevailing in the river. From many field investigations it was apparent that the mean concentration of a pollutant at a cross-section might not therefore be representative of the pollution in the river.

The integrity of the model was influenced largely by two factors:

(1) the velocity profile perpendicular to the cross section must be known;

(2) at least a fair estimate must be made on the transverse dispersion coefficient.

Dr Starosolszky believed that it was important to initiate international co-operation in assessing water quality in large rivers. He had made this point at the closing conference of the International Hydrological Decade in 1974 and although a UNESCO/IHP working group had been established for studying mixing conditions, he believed that the need for better, more accurate understanding of the dispersion coefficient for future water quality modelling should not be underestimated.

(b) Comments by Mrs M. Puskás (District Water Authority, Budapest)

In the Hungarian section of the Danube, some 400 km long, uniform water quality at a cross section was virtually unknown. The quality was said to be non-uniform if the scatter of analytical results was greater than the error of observation (uncertainty of sampling and reproducibility of analytical methods).

Therefore a number of sampling points was chosen taking into account the channel configuration, the width of water surface and the distribution of flow velocity. Mrs Puskas said that samples in the Danube were usually taken from a launch from four-six depths at each of five-nine verticals i.e. from 20-54 points.

To determine the observation error, five samples were taken simultaneously from a single section of each of which five parallel analyses were made for each determinand.

From the analytical results, iso-concentration curves were derived which demonstrated the non-uniformity of the water quality at the cross section.

These results in association with the flow distribution at the section were used to compute the pollution load. The cross-section analysis work was too time-consuming to be performed frequently, but results did suggest sampling locations where a representative sample could be obtained with that flow distribution.

The results showed however that different sampling locations were necessary to obtain representative samples of different water quality components. Again, these largely depended on the flow and if an accurate assessment was required, sampling from a number of locations had to be carried out.

(c) Comments by Mrs M. Abrahám (District Water Authority, Györ)

Mrs Ábrahám said that 141 km of the Danube from stations 1850 to 1709 were the responsibility of her authority. Of this length, 140 km formed the Hungarian frontier and upstream of the Rajka cross-section the Danube received domestic and industrial effluent. Information on water quality, the determination of trends and the rate of variation of quality was essential to water abstractors in Hungary.

For this reason, regular weekly sampling had been introduced almost 10 years ago and some quality characteristics had been measured and registered continuously for the past year by the monitoring station built under the Project. The pollution load and its distribution arriving at the Rajka cross-section had been assessed quarterly since 1974.

Results showed that the biodegradable organic load was steadily increasing as was the concentration of plant nutrients. The frequency and severity of oil pollution arriving at the cross-section displayed a similarly increasing trend which affected the entire length of the section under the jurisdiction of her authority.

To be able to assess the water quality of this section of the Danube it was essential to be able to have access to data about the pollution sources upstream of the Rajka cross-section as well as the sources discharging to the section. Without this information, it was impossible to prepare a reliable hydro-chemical profile. Nor could the assimilative capacity of the river be taken fully into account unless details of the pollutants were known.

No country, however strict it was in its own territory, was capable alone of preventing, or even moderating, the present rate of quality deterioration. Protection of the river water quality called for coordinated efforts in the entire river basin by all interested countries.

(d) Comments by Mr I. Matrai (Water Management Institute, Budapest)

The total installed power generation capacity on the Danube was estimated to be about 8000 MW and of the 31 barrage projects contemplated between Regensburg and the Black Sea, 12 had already been completed and the construction of several others had been approved.

The construction of the Gabcikovo-Nagymaros Hydroelectric Project was a joint venture between Czechoslovakia and Hungary and it was the possible effects on mixing and hence water quality due to the changed hydrological conditions that he wished to discuss.

The main elements of the Project comprised the Dunakiliti Dam and reservoir, the 25 km navigable canal which would provide the water power, the Gabcikovo power generating station and, further downstream, the Nagymaros power generating station. The power canal would carry the high normal-flow of 4000 m^3/sec and exceptionally 5270 m^3/sec and only the obligatory flow of 50 m^3/sec would be allowed down the Danube, except in times of flood. The 200 km^2 flood plan would therefore be inundated much less frequently.

The Gabcikovo power station would operate once per day at times of normal flow and twice per day at times of high flow. The turbine discharge would vary widely, e.g. at a streamflow rate of 900 m^3/sec, the discharge would vary from 0 to 4450 m^3/sec and unsteady conditions would be created with flows which would resemble the passage of flood waves characterized by a steeply rising front. At the flow rate of 900 m^3/sec the water impounded over 18 hours would be released in six hours. The rise in water level would exceed 4 m downstream of the Gabcikovo barrage but would still be of the order of 1 m at the mouth of the Vaj River. The passage of the flood wave would cause the flow to be reversed at low streamflow rates. It was predicted that the polluted plume of the Vaj which could be detected 50 km downstream would be subjected to much more intensive mixing than under the present flow regime.

Thus it had been found advisable to extend the mixing studies to unsteady conditions in order to explore in more detail the impact of the Gabcikovo-Nagymaros project on water quality.

2.5 Assessment of water quality, bio-resistant materials, bottom sediment, etc.

2.5.1 Introduction by Dr P. Literáthy (VITUKI, Budapest)

The control of micropollutants, mainly bioresistant substances of industrial origin, was an important part of water quality management. One of the main objectives under this section of the project had been to study these pollutants and, as a result, to characterize water quality changes.

The River Sajó which was heavily polluted by bioresistant substances, mainly heavy metals, which accumulated in the bottom sediments and could be released from them, had been the subject of a detailed study. One benefit had been the establishment of a suitable technique for sediment analysis. Following the work carried out under the project, an investigation had been carried out to assess how the Sajó River affected the sediments present in the Kiskore Reservoir.

Bioresistant substances had also been investigated in the Danube and special attention had been paid to mercury which had a characteristic feature, viz. its heterogeneous distribution in a cross-section. The mercury concentration in the Danube exceeded the toxic limit in several cases, but the concentration had shown signs of diminishing in 1976 and 1977. Bottom sediments from the Danube had also been analysed for mercury. Though the content of these was much less than those from the Sajó, it was still high enough to be harmful to aquatic life and undesirable in water abstracted for treatment for drinking purposes.

Further investigations should be carried out on the subject.

2.5.2 Total river basin assessment of sediment-erosion-transport-deposition processes by Dr G. Fleming (University of Strathclyde, Glasgow, United Kingdom)

Dr Fleming said that river basin sediment processes were central to the assessment of both hydrological and water quality variables. All must be fully understood in order to formulate effective plans for river basin management. The three facets of water resources assessment were complex since they were an aggregate of the many inter-active sub-processes which varied with time and space with a mixture of deterministic regularity and stochastic variability. Added to this was a river basin with international sub-catchments and the result was an addition to the problem of all the socioeconomic, legal and political facets of water resource assessment. The decision-makers would need assessment sound scientific techniques which could adequately represent the many component processes which contributed to river basin response.

This outline of the processes as they related to practical sediment problems, existing methods for assessing sediment processes, including measurement, empirical formulae and mathematical models, led to a discussion of the relevance of mathematical modelling of river basin sediment processes of the river Danube.

2.5.3 Discussion

(a) Comments by Mr F. László (VITUKI, Budapest)

One of the difficulties in presenting the results of bottom sediment analysis was their interpretation. It was only partially possible to differentiate between components of a geochemical origin and those due to human activities. The latter was incorporated mainly in the ignition loss and in the acid-soluble part so that it might be a better way of assessing the pollution rather than relating it to kilograms of dry substance which was the common practice.

A reasonable way of obtaining the quantitative content of polycyclic aromatic hydrocarbons was through the total amount of extractable substances, because the relative change indicated the degree of bioresistance. The critical stages were separation and proper detection.

In the case of heavy metals analyses, an important process was digestion and for atomic absorption spectrophotometry, nitric acid plus hydrogen peroxide mixture had been found to be suitable. For mercury it was important to know the portion of some forms as well as the total content.

The unidentified organic pollutants present in bottom sediments caused considerable analytical problems. Gas chromatography fingerprints were helpful, particularly in providing information about changes along a watercourse. Identification of the constituents separated by thin-layer chromatography was usually attempted by infrared spectrophotometry, while GC separated compounds could be identified by a gas chromatograph-mass spectrometer system.

(b) Comments by Dr P. Benedek (VITUKI, Budapest)

Suspended solids in the Danube varied from 30 to 100 mg/l but in floods could be as high as 1500 mg/l. Plankton floating in the water consisted mainly of diatoms, the assimilated brown pigments of which gave the brown colour to the water. The bottom consisted mainly of gravels, gravelly sand and sandy loam and the biomass of the bottom fauna amounted to only 5-6 g/m^2.

Three factors were dominant when considering the prospective water quality of the Danube: the rapidly growing industrialization in that part of the catchment area covering the CMEA countries, the growing urbanization and reduction of flow velocity caused by the water barrages either under construction or being planned. Three barrages were to be constructed, for example between Bratislava and Budapest, and the planning of the Gabcikovo-Nagymaros Barrage was at an advanced stage.

The effect of the barrages would be that the time of travel of water over the 200 km would be increased from two to five and a half days and the average velocity would decrease from 122 cm/sec to 40 cm/sec.

Over a 70 km river stretch downstream from Bratislava, the suspended solids had shown a 30% fall-off. This would increase to an estimated 55% after the construction of the Bratislava and Gabrikovo barrages. In addition, the decomposing organic and pathogenic microorganism content would result an anaerobic decomposition with consequent oxygen loss in the bottom sediment. This would create better conditions for the growth of zoo-benthos and it was expected that the bio-mass might reach over 100 g/m^2 in backwater reaches above the barrages. No significant changes were expected in the floating zoo- and phytoplankton which would probably still continue to be dominated by diatoms.

The above-mentioned factors made it necessary to have representative, reliable data in order to forecast the water quality which would result from the construction of the barrages and increase in pollution load.

It might also become necessary to prescribe water quality standards for the numerous important tributaries at their confluence with the Danube. Drinking water supplies were vital to the riparian populations. For the efficient development of these standards, reliable data were also needed.

In the project, Hungarian water management bodies had worked out advanced water-quality monitoring principles which had been tried on the Hungarian part of the Danube and might be of interest to all riparian countries.

(c) General discussion

The discussion focussed on the practicability of being able to model the whole of the Danube basin along the lines that Dr Fleming had suggested in his lecture. Doubts were expressed about the amount and cost of the data collection that would be necessary.

The objectives of such a model must be thoroughly understood and for it to become a practical proposition there was an overwhelming need to rationalize data collection, which was not as integrated as it might be, some being under-used and some not used at all. Of special interest were the bioresistant substances, which became adsorbed on to sediment particles, and the changes that occurred between their dissolved and solid phases, another reason for modelling the sediment movement in the basin as a whole. Moreover, while retention times for water in reservoirs behind barrages were quoted, short circuiting would occur at certain flows and make nonsense of a model's results.

An alternative scheme, of making statistical analyses of the data on 100 years discharge and 30 years sediment was advocated, but it was pointed out that this approach would have to be treated with caution because of the number of variables involved, e.g. wet versus dry weather and land use.

The timescale for the development of a large model was important. It was really needed before the barrages were built.

Dr Fleming suggested that a common basis for analyses would have to be chosen for the comparison and exchange of data, that, with wholehearted cooperation, one year would be needed to assemble the data, that a first-order sedimentation model could be ready in one year and a complete model within three years. He advocated modelling sub-basins, e.g. the Tisza and the Morava and integrating these. Similarly the main river could be divided into segments according to the different slopes, soil characteristics, whether there was a reservoir, and so on. While model makers did not understand the whole process, they understood very clearly what was practical. It was his belief that an integrated model for the whole of the Danube encompassing hydrology, sediments and water quality should be constructed and was practicable. He quoted the example of a river basin in South America which he had modelled. This had a catchment of 747 000 km^2 and five reservoirs had been planned for it. This work, under extreme pressure (and at high cost) had been completed in four months.

2.6 Legislative methods used in Hungary for water quality management

2.6.1 Introduction by Dr A. Homonnay (VITUKI, Budapest)

Economic incentives had proved to be successful in encouraging the necessary investment in effluent treatment plant. If the necessary plant were not installed, the basis for fining the offender was the amount he should have paid to treat the wastewater. Continual infringement and the consequent fines were such that over a period, offenders would pay or exceed the sum necessary for the installation of the proper treatment facilities, based on capital plus operating costs.

To permit this course of action, current legislation had had to be revised to allow its introduction on a country-wide basis, while adhering to a practicable technical framework.

2.6.2 Discussion

(a) Comments by Mr E. Katona (National Water Authority, Budapest)

Mr Katona recalled that before 1945 water management activities in Hungary had been almost exclusively confined to water licensing, but this on its own had proved inadequate. The foundations for a more advanced regulating system were laid in a Government order in 1961 and followed by a bill in 1964 which subsequently became known as the Water Act. Both measures had since been frequently reviewed and improved by the enactment of additional legislation.

Dr Homonnay claimed that the legislation had proved to be effective and comparable with any elsewhere in the world. He supported this claim by producing evidence of the changes in the water quality situation recorded, using a definition of efficiency of water management as the ratio of streamflow rates to pollution loads carried by the water.

The quantity of polluting substances discharged into receiving waters by industrial and agricultural operations, communities and institutions had increased quickly at first but, starting in the late nineteen-sixties the rate of increase had diminished, in spite of the fact that the economy had developed vigorously throughout the period.

A slow increase in mass flow of pollutants entering the country had also been recorded. The overall pollutant load balance for the country was still considered acceptable, since the pollutants leaving Hungarian territory had been reduced by 33%. Thus the water discharged to downstream users was, with few exceptions, cleaner than that received. To maintain and improve this situation, a sum of almost 25 000 million forints (US$ 1 200 200 000) had been authorized for the fifth five-year planning period.

The present water quality management regime had evolved under the combined impact of those processes and was still effective. The objective, to control the accelerating rate of water pollution, had been achieved.

However, in the future, the amount of pollution generated would continue to grow and the available water in dry weather would diminish; the incidence of accidental pollution would increase both in frequency and in the damage caused, and new sources of harmful pollution would arise. The combination of these factors could result in a substantial deterioration of water quality which Hungary would not be able to tolerate. It therefore followed that the institution of remedial measures was one of the most important tasks of water management and environmental protection in general. In particular, an imporvement of the regulatory system was necessary, because in its present form it would no longer be capable of containing the future situation.

(b) Comments by Dr P. Pásztó (Water Management Institute, Budapest)

The concept of the environment as a whole had not appeared in Hungarian legislation until the early seventies, but there had been earlier efforts at control in various sectors; for example, water quality had been protected since the turn of the century.

The interaction between the individual sectors had only been recognized in recent years, in the passing of the Environment Protection Act, but some revision of the legal measures had taken place in parallel with this prior to the integration envisaged in the Environment Protection Act. For example, the "fining for pollution" legislation had been revised seven times since 1961 and, as Dr Homonnay had pointed out, more revisions were to be expected.

While the public would welcome more universally stringent standards, there were those whose economic philosophy was "living standard" orientated and who advocated the application of different standards based on the assimilative capacity of the sector at the point of discharge. Legislation itself, and its enforcement and compliance, all lagged far behind the demands of society for the protection of the environment in general, but in particular because of man's increasing exploitation of it.

Advances in technology and economic progress imposed a patchwork character on legislative actions. A mass of variously permissive, restrictive and prohibitive measures and economic incentives had developed and needed to be rationalized. The legislators found themselves in an unusual position; instead of deriving the general principles for the formulation of socio-legal concepts from analysing living conditions, they were compelled to draw the philosophy of legal regulation from a poorly defined set of environmental concepts.

It should be noted that the term "environment" did not stand alone; it had to be the environment of something or somebody. Thus the term "environment" must be understood to cover the human environment. Environmental protection was not an end in itself, it must serve the interests of man. Mistakes had been made when this basic principle was forgotten.

Due to the complexities in considering the environment as a whole, the hydrologist should limit his concept of the environment to the biosphere. This was understood to be the physical environment inhabited by living organisms in which movement was maintained by the energy of the sun. Thus the elements comprised the atmosphere, the hydrosphere and the lithosphere.

Environmental protection comprised a set of functions having the objectives of:

- protecting man from environmentally harmful effects;
- controlling the detrimental impact of natural resources;
- husbanding available natural resources;
- developing the assimilative and regenerative capacity of the environment in the interest of human welfare.

The solution of this set of functions consists in optimizing the tension between the environmental demands of society and the ability of the environment to endure the social impact of pollution.

In water quality management (which also comprised the four functions above) it was not enough to control the interchange of pollutants in the hydrosphere alone, because the latter was closely related to the atmosphere and lithosphere. Thus, the substances decomposed or reclaimed in the course of wastewater treatment must be harmlessly disposed of in the hydrosphere (eutrophication) in the lithosphere (sludge disposal) or in the atmosphere (sludge incineration). Moreover, in this process, even the interchanges between the different sectors had to be regulated.

In addition to wastewater treatment, there were a number of alternative techniques which might be adopted, such as the storage and periodic release or recycling of wastewaters by industry, the use of diluting water released from a reservoir or the reoxygenation of streams by artificial re-aeration.

Finally, Dr Pásztó turned to planning. It was no use now dealing piecemeal with effluents as and when they arose. The entire system of interregional and interresources impacts of volumes and qualities had to be appreciated and planned for and the implementation of all aspects of the system had to be enforced by legislation. Thus, future legislation must be founded on systems planning and, in the law itself, the legal sanctions in water quality management must be established, including fines, the payment of damages and criminal prosecution.

2.7 Water quality models as a tool for modelling

2.7.1 Introduction by Mr B. Hock (VITUKI, Budapest)

The objective of formulating a mathematical model was to develop a tool for decision-making by management. The basic concept of a water quality management model was to optimize the net annual sewage and wastewater treatment costs, taking into consideration the river water's quality and self-purification characteristics.

On the above principle, the objective was defined as being the development of a complex model which took into account the hydrological conditions of the Sajó, set the river water quality standards, related a system of alternative sewage and wastewater treatment technologies to the most important point pollution sources and selected an economically optimum solution by minimizing the net annual costs. The model was designed to operate over a long time period and sewage and wastewater discharge data for 1985 would be predicted.

The implementation of the programme would result, even in low flow conditions, in achieving along the total Hungarian length of the Sajó (one of the most polluted watercourses in the country), a water quality at least as good as CMFA quality standard Class II. This would in turn make a contribution to improving the quality of water in the stretch of the Tisza River immediately downstream from its junction with the Sajó.

2.7.2 Discussion

(a). Comments by Mr L. Balázs (District Water Authority, Miskolc)

Mr Balázs said that the Sajó basin through its industry contributed 12% to the gross national product of Hungary and accommodated 7% of the population. The water resources of the basin were 90% fully utilized and each downstream factory was forced to re-use the polluted effluents discharged into the Sajó by those situated upstream.

The growth of the present water management system in step with industrial development could not yet be considered effective in controlling either the quantity or quality of the water. The principal task of any water authority was to ensure that the users had sufficient water of a quality suitable for their needs and that future demands for additional water could be met.

Thus, the problem consisted in ensuring the rationalized operation of existing facilities such as treatment facilities, abstractions, and storage reservoirs, and the development of new ones so that the optimal operation of the system as a whole could be guaranteed in future.

This made it essential to provide the requisite quantity of water of suitable quality at least cost ("cost" being the sum of capital plus operating costs).

There were many matters to be considered: abstractions, inter-plant water management, recirculation and water management cooperation on an international level. Consideration had also to be given to the pretreatment of polluted waters within plants, the reclamation of valuable materials and advanced wastewater treatment. There was also the possibility of projects to enhance the flow through storage and transfer of water, whereby the allowable pollution load might be increased. After consideration of all these and all appropriate combinations thereof, the optimal solution should be found within the practical limits of the time and funds available.

Among the measures already taken were the development of closed water use systems and series connexion of circulation systems, reduction of effluent volumes discharged; treatment of effluents, cooperation between industries, etc.

In recent years, pollution had stopped increasing as a result, the quality of some surface waters had improved and water management by industry had also become more efficient. Water quality management decisions however were becoming increasingly difficult to make because of the complexity of the system. The advent of the mathematical model was therefore a great help.

(b) Comments by Dr G. Jolánkai (VITUKI, Budapest)

One effort under the project had been to establish how far downstream of certain key effluent discharge points on the Sajó river it took for total mixing to occur. The purpose of this work was to establish for all important sources of pollution whether it was reasonable to assume perfect, instantaneous mixing, as had been done in the model. This had turned out to be a fairly realistic approach because complete mixing had occurred within 1000 m of the discharge point for each case examined and was much less than the scale of reaches used in the model.

Although the work was only a small item in the project, some interesting facts had become apparent. For example, it had soon become evident that the use of conventional tracer techniques should be avoided because:

- the pollution at most sites was so great that very high tracer concentrations were necessary;
- from the practical viewpoint, a continuous release of tracer was desirable to discover the shape and extent of the plume. This would have involved still greater quantities of tracer with consequent expense;
- repeated studies at very short notice were needed at many sites which necessitated the introduction of some very rapid and effective method.

The solution to these problems was to use tho so-called "natural tracer" technique where a clearly distinguishable quality characteristic of the effluent discharge under examination was selected as the tracer. The field work then comprised the following steps:

- flow rate measurement in the receiving water downstream of the discharge;
- discharge measurement of the effluent;
- frequent quality sampling of tho effluent;
- background quality sampling upstream of the source;
- sampling in at least two cross-sections downstream of the sources with a minimum of 10 samples taken at each section.

Finally, the method for computation of the results was described. A combination of rapid and cost effective field studies and computerized modelling would enable management to deal with increasingly complex situations.

(c) Comments by Dr Á. Fázold (District Water Authority, Miskolc)

Water quality had been surveyed intensively on four occasions at different flows along the Sajó River to determine the assimilative capacity of the river for pollution at each. On each occasion, between 48 and 68 samples had been taken over the 124 km length of the river in Hungary, including samples taken simultaneously from the effluent discharges. From the results many longitudinal profiles had been constructed.

The results of the assimilation studies showed that regardless of the improvement in COD values the quality of water in the Sajó was still far from satisfactory. One of the principal problems was due to the lignine sulfonic acid contained in the river water as it entered the country. It did not decompose and its concentration diminished only as a result of dilution. Another was the total dissolved solids content which resulted in additional industrial water treatment costs at abstraction points.

It was realized that within the water quality management system of the Sajó, the water management practice by the successive industrial undertakings depended on, and interacted with, each other. Because of the significance of total dissolved solids to industry, it was decided that they should be modelled mathematically on a stretch, divided into three sub-reaches, between the border and the town of Miskolc. Over the section, three tributaries and five effluent discharges were considered. Three objectives were established:

- to prevent the quality of water entering the country (as background pollution) from deteriorating further and to make the best use of the diluting effect of the Bodva creek;
- to ensure that the total dissolved solids should meet legal requirements, <u>viz</u> they should never exceed 2000 mg/l in the effluents; (This called for considerable reductions.)
- to ensure that the total dissolved solids in the Sajó should meet CMEA standards for Class I water quality i.e. $c_{max} \leq 500$ mg/l. (It was recognized that this would be idealistic and could not be attained even in the distant future because the water entering the country failed to meet the standards.)

The water quality model provided the basis for economic analyses which after further data had been collected could also be used in compiling an economic model. This was important because, if water quality of Class I were available, the capital cost of the treatment plant at one factory could be reduced by 82 million forints (US$ 3 942 000), the cost of treatment chemicals by 40%, saving about 10 million forints (US$ 481 000). Also by complying with the legal requirements, the chemical industry would save about 100 million forints (US$ 4 810 000) over a five-year period.

(d) Comments by Mr K. Röszler (Water Management Institute, Budapest)

The growth of population, urban development and the increase in agricultural/industrial production needed to improve the standards of living had sent water demand rocketing in recent years. Fixed resources had therefore made water management essential.

Wastewaters had been produced in increasing volumes which had resulted in increasingly heavy pollution of both surface and groundwaters, which thereby became unsuitable for re-use, or required extensive treatment. Thus the growing demand for water was being accompanied by an increasing need for water quality protection.

Regional water management planning was not related to political or national boundaries but to hydrological boundaries, and water management problems could not be solved by remaining confined to the boundaries of political entities.

Regional planning was a complex problem in which water quality management was of great importance. The results of the UNDP/WHO-assisted project were expected to make a substantial contribution to these tasks. The experience gained had demonstrated that in planning, the regional and comprehensive approach must be extended still further and must not be restricted by national or political boundaries. Ideally, they should also include the air and soil sectors too.

2.8 Highlights of the discussion

2.8.1 Demand for water

The growth of population, urban development and the increase in both agricultural and industrial production needed to improve the standards of living of the people had caused the demand for additional water supplies to increase rapidly.

The riparian countries were concerned to preserve unobstructed navigation on the Danube, but this could not be maintained without the construction of a series of barrages across the river. Hydroelectric power generation would mean that these barrages would help meet the additional electrical energy needs of the riparian states.

2.8.2 Resources

No less than 96% of the surface water resources of Hungary originated in other countries. While there was still some potential for further development, the supplies of good quality groundwater were for the most part fully utilized.

The Danube was the principal source of water and it was envisaged that even the shortages that occurred from time to time in the Tisza valley would be alleviated in the future by water transferred from the Danube.

2.8.3 Quality considerations

Over almost its entire length, the Danube was at present capable of assimilating the pollution load from the offluents discharged to it. Some of the determinands in the Hungarian section of the river however, especially bio-resistant substances, had already attained the limit beyond which wastewater treatment was necessary. For water contact recreation, the critical water quality determinand was the faecal coliform count. The count for the Danube varied from 10-60 times the recommended limit of 2 mg/l. It therefore followed that the river could not be recommended for water contact recreational purposes.

To assess the water quality of a section of the Danube, it was essential to gain access to data on the pollution sources upstream as well as the sources discharging to the section. This was not always available, but without the information, it was impossible to prepare a reliable hydro-chemical profile. In addition, the assimilative capacity of the river could not be taken fully into account unless details of the pollutants were known.

The relatively low level of sewerage, the rapid development of industrialization, the changeover to intensive farming methods and the further rapid development of urbanization meant that an increase in pollution was unavoidable unless strong countermeasures were taken.

No country, however strict the measures it introduced in its own territory, was capable alone of preventing, or even moderating, the present rate of quality deterioration. Protection of the quality of the river water called for coordinated efforts in the entire river basin by all interested countries.

2.8.4 Automatic water quality monitors

The philosophy of the use of automatic water quality monitors was questioned. It was thought that too much was expected of them in terms of accuracy and the view was expressed that it was relative measurement that was needed, i.e. changes in value were more important than absolute values. If that were accepted, the need for accuracy was not so important and many sensors, particularly selective ion electrodes which had previously been discarded on the grounds that they were insufficiently accurate, would be worth re-examining for possible use. If that were accepted, measurements could be made of pollutants that were of real interest rather than the ones being measured at present.

It was not thought to be economically advisable to invest in additional automatic water quality monitoring stations before the required sensors had been developed; the principal immediate task was, therefore, that of sensor development.

It was nevertheless conceded that automatic water quality monitors had a role to play, even though they were of limited use at present. Careful thought should be given before making a recommendation to install an automatic monitor. In particular, cost/benefit should be examined.

2.8.5 Mathematical models

The objective of formulating a mathematical model was to develop a tool for decision-making by management. The basic concept of a water quality management model was to optimize the net annual sewage and wastewater treatment costs, taking account of river water quality and self-purification characteristics.

River basin sediment processes were central to the assessment of both hydrological and water quality variables. All must be fully understood if effective plans for river basin management were to be formulated. While it was admitted that model makers did not understand the whole process, they understood very clearly what was practical. An integrated model for the whole of the Danube system, encompassing hydrology, sediments and water quality should therefore be constructed.

The practicality of being able to model the whole of the Danube basin along the lines suggested was questioned. While there was agreement in principle that it would be a good thing, doubts were expressed about the amount and cost of the data collection which would be necessary. To obtain any practical proposition at all, there was an overwhelming need to rationalize data collection by the riparian countries, because some were being underused, some were not used at all and some were not yet collected. As a first step, for the construction of a model, the importance of international cooperation in this field could not be overemphasized.

2.8.6 Environmental protection and its impact on water resources management

Environmental protection consisted of a set of functions with the goal of:

- protecting man from environmentally harmful effects of pollution;
- controlling the detrimental impacts of natural resources;
- husbanding available natural resources;
- developing the assimilative and regenerative capacity of the environment in the interest of human welfare.

It should be noted that the term "environment" did not stand alone; it had to be the environment surrounding something or somebody. It must thus be understood as covering the human environment. Environmental protection was not an end in itself, but must serve the interests of man. Mistakes were made whenever this basic principle was forgotten.

For example, it was no longer any use dealing with effluents on an *ad hoc* basis as and when they arose. The entire system of inter-regional and inter-resources impacts of volumes and quantities had to be appreciated and planned and the implementation of all aspects of the system must be enforced by legislation.

While the public would welcome more universally stringent standards, there were those whose economic philosophy was "living-standard" orientated; they advocated the application of different standards based on the assimilative capacity of the sector at the point of discharge. Legislation itself and its enforcement and compliance, all lagged far behind the demands of society for the protection of the environment in general, but in particular because of man's increasing exploitation of it.

Advances in technology and economic progress imposed a patchwork character on legislative action and a mass of severally permissive, restrictive and prohibitive measures and economic incentives had developed which needed rationalizing. In the water sector, regional planning should not be related to political or national boundaries but to hydrological boundaries. Water management problems were impossible to solve in area units confined to political boundaries.

3. STATEMENTS BY PARTICIPANTS

3.1 Participants from individual countries

Statements by participants from the countries present were given outlining the activities in which they were engaged. These are summarized below:

3.1.1 Austria

(a) Dr K. Megay, speaking in his personal capacity, said that as he was an observer he was not authorized by the Austrian Government to give a statement concerning the future programme of activities in the field of water quality control in Austria, but so far as water quality in the River Danube was concerned, efforts were being made to ensure by permanent controls that at least the present state would be maintained and pollution by sewage would be avoided. Between Linz and Vienna, the water of the Danube and the groundwater in its vicinity were subjected to frequent and regular chemical and biological assay and efforts had been made to promote sewage treatment for domestic and industrial wastewater.

Problems of water quality were being studied continuously by different scientific institutes belonging to universities and federal government authorities.

(b) Dr J. Sas-Hubicki, speaking as a WHO temporary adviser, said he was concerned that future activities should be planned. He gave a general description of the Austrian hydrology network of stations to record hydrological and meteorological data. This was now complete and included models for predicting flood levels. Some of the Danube stations transmitted data automatically to a central computer in Vienna. From the data, river levels were predicted in flood or other unusual conditions. There were also some water quality monitoring stations and more were planned to keep pace with the development of new projects such as hydroelectric plants, river ports and new industrial sites. A large sewage treatment works for Vienna was under construction to the east of the city. Austria was on the point of putting all its records on computer, and a feasibility study had been started, which was looking at the available dictionaries, systems and programmes, in particular those produced in the Federal Republic of Germany and United Kingdom Water Data Unit in Reading.

Describing the useful contacts with colleagues in neighbouring countries both upstream and downstream, he wondered whether, in helping to simplify the complicated task of bringing the appropriate people together, the way ahead in cooperation would not be to try to agree on a standard dictionary of determinands, both chemical and biological; to try to agree on standardized sampling methods; to try to agree on synchronized sampling programmes from time to time, and to arrange for the different computers to be fed with common information, for example by the exchange of magnetic tapes. At the same time he conceded that the fact that not all countries used the same chemical and biological language made for difficulties.

3.1.2 Czechoslovakia

Mr R. Chrast speaking on behalf of the Czech participants noted that a common feature of most of the papers had been the stress laid on the complexity of water quality control problems and on the needs for more in-depth research. Some speakers had also pointed out that effectiveness in solving water quality control problems on an international river would be promoted by international cooperation. Some areas of possible cooperation had also been suggested.

Various aspects of water quality had been among the main problems investigated during the UNDP/WHO project in Czechoslovakia concluded successfully in March 1977. Problems of water quality control also formed an important part of the activities of the Czechoslovak Centre for the Environment in Bratislava.

After a detailed evaluation of results so far and in the light of needs expected to arise as a result of further development, it was considered useful to extend gradually the scope of cooperation in solving environmental problems. His country's water management bodies could effectively contribute to such cooperation, particularly as regards methods for water quality evaluation and development, and as regards the application of mathematical models.

In Czechoslovakia, a water quality monitoring network for main profiles and main sources of pollution had been designed and was being implemented gradually. On the Ohre River, as an interim stage, the network was designed to measure dissolved oxygen, conductivity, turbidity, pH, redox potential, and organic matter absorbed in the uV range. Other parameters were also to be monitored at a later stage. The objective of the work was to establish an integrated water management system for the Ohre River. In his country, they were fully aware of the advantages, and disadvantages, of automatic monitoring stations. The main effort was centred, however, on steadily upgrading classical monitoring systems, based on manual methods.

Apart from the physical-chemical parameters, considerable attention was also devoted to microbiological, virological, etc., aspects of water quality, including the incidence of heterotrophic bacteria, entero-bacteria and viruses. Investigations were also going on into biomass production, the production of biogenic oxygen and trophic potential. The problems of standardizing methods of water quality management and evaluation were considered to be very important. Simple mathematical models had been applied, in some cases, to establish the relationship between some water quality parameters and river flow. For smaller rivers, several types of simulation models had been used, depending on the objectives of studies. Eutrophication models had been developed as well, based either on statistical analysis of directly relevant variables using observed values, or on the quantification of relevant processes and simulation of variables. They were also developing dynamic systems for real-time management of selected river systems.

3.1.3 Federal Republic of Germany

Dr P. Kothé described the present investigations of the Federal Institute of Hydrology into the water quality of the river Danube. They mainly concerned a navigable stretch of the river from Danube km 2415 to the Austrian border. In this reach, a large navigable canal linking the rivers Rhine, Main and Danube, was being constructed. Under Federal German law, planning permission was required before regulation or construction of new federal waterways might be undertaken, to ensure that the intended works would not cause harm or that measures would be taken to minimize unavoidable damage. For the purpose, evidence of the river's condition must be obtained before construction work was started, and for the canal project, the Federal Institute of Hydrology had been mapping underwater and riverbank plant associations; making chemical and biological examinations of surface waters, including a biological inventory of the bottom population and of the periphyton (benthos) in the longitudinal profile of the entire reach of the Danube river bottom, banks, tributaries and abandoned channels; drawing up longitudinal oxygen profiles covering day and night variation curves in oxygen content; seven-hour biochemical oxygen demand, additional consumption for peptone and glucose, oxygen production potential, and the "biogenic aeration rate"; and carrying out special investigations into fish food organisms. All that was in addition to the studies being made by Bavarian institutes on river-fishing conditions, chemical examinations of Danube river quality, in normal and flood conditions, and quantitative hydrological measurements.

In addition to investigations being conducted in connexion with planning permission for navigational works, routine measurements taken by Bavarian agencies for monitoring water quality were concerned with the maximum reduction of pollutant wastewater discharges, including monitoring of settling solids (COD), toxicity relative to fish and the mercury and cadmium rates. One aim was to ascertain the effects of wastewater discharges and the pollution load carried upstream from water abstraction points.

Other specific studies by the Federal Institute of Hydrology in recent years had been measurements of the carbon budget to determine the proportion of bioresistant organic substances in the Danube river water, and a programme, over several years, which investigated the relationship between the colonization of the river bed by benthid organisms and the bedload transport.

Besides the Federal Institute of Hydrology, a number of other academic and government agencies and scientific institutes, engaged in research work on the Danube and its tributaries, were grouped together in the German section of the International Working Group for Danube Research. (IAD, Internationale Arbeitsgemeinschaft Donau.) Under the IAD, cooperation with experts and research institutes in other riparian countries of the Danube was maintained on a non-governmental basis. This cooperation and teamwork ensured international contacts along the Danube, without imposing on the national authorities.

3.1.4 Hungary

Mr L. Tóth said the seminar had proved again the productive and useful cooperation that could be maintained between the bodies of the United Nations and different countries, and had shown that Hungary had been able to benefit from the scientific and technical potential created by the assistance of the UN agencies. The seminar had shown that similar methods of cooperation among several countries would make it possible to obtain comprehensive results for other international rivers and great lakes. Improved protection for European rivers, among them the Danube, was a matter of urgency for all the affected countries. The deterioration of water quality was a danger to economic development, to the hygienic situation and to the protection of nature.

The water management bodies in Hungary had been active in such United Nations efforts as the UN Water Conference and the ECE Committee on Water Problems. Hungary had bilateral agreements on water management with neighbouring countries; played an active part in similar activities of CMEA; supported the Bucharest initiative and was active in its work. His country considered that all these efforts would help it make better progress in the common cause and contribute much to the water protection of Danube and other waters.

3.1.5 Poland

The Polish participants, Mr B. Skowyrski and Mrs B. Stoch, indicated that in Poland a national research and development programme on the utilization of water resources had been prepared, providing a basis for water management and protection of water resources. In drawing up these regional and other programmes, experience gathered in Poland, abroad and from international organizations was taken into consideration. That included the results of the project on "Pilot Zones for Water Quality Management".

Of all the themes important for overall water quality control, simulation models of the pollution process and data collection for use in the quality control of water were the most important.

He was sure that for the improvement of water quality protection, the positive results achieved in the UNDP/WHO-assisted project and research by Hungarian water experts should be continued and further developed.

The results and proposals of the seminar might be useful for the countries involved, both in the proper selection of scientific research and design approaches and in speeding up the answers to a great many difficult problems, such as simulating water pollution or in constructing water protection programmes.

3.1.6 USSR

Dr P. Khalitov said that in assessing the value of automatic water quality monitoring systems, it should be remembered that all they were intended to do was to determine, comparatively quickly, certain chemical constituents. He felt that at the present time it was advisable to use both automatic and conventional methods for epidemiological chemical investigations. In microbiological analyses, of equally great epidemiological importance, only the traditional methods were yet available. Nevertheless, automatic monitoring instruments had good future prospects.

A general plan for utilization and conservation of water resources until 1980 had been formulated in the USSR in the early nineteen-sixties. Among those who had played a part in this planning activity had been designers, water management, hydrology, epidemiology and sanitation experts. The involvement of the latter group had ensured close attention to the hygiene needs of the Soviet public, in any case protected by law. Part of the planning had included local projects for the protection of certain rivers, lakes and seas (for example, in the Volga and Ural rivers, Lake Baikal, and in the Black Sea, the Baltic and the Caspian). Large investments had been allocated by the government for water protection, and for example almost all of the cities along the river Volga were now equipped with effective biological sewage treatment plants.

Industrial establishments in the Soviet Union had been active in improving technological processes and water management balances (including the use of non-water technology), water reuse and the design of wastewater treatment plants; legislation empowered hygiene and water management bodies to shut down establishments with no wastewater treatment plants and which were not prepared to take water protection measures in good time. New industrial establishments were not permitted to start operating if they did not have wastewater treatment plants. At present, they were formulating a general scheme for the overall utilization of water resources up to the year 2000. The Danube problem was a very difficult one for water management in the Soviet Union because by the time the Danube reached the USSR it was carrying the residual pollution from all the countries upstream. Stressing the great value of the work carried out by the Hungarian experts in water quality management in the pilot zones, he expressed the hope that the bodies concerned would find much that could be of practical use to them.

His country was ready to cooperate with all the riparian countries. Its offer stemmed from Soviet foreign policy, which states the willingness of the USSR to cooperate with all other countries in environmental protection problems. The Kiev Institute of Hygiene and other establishments of epidemiological and sanitary service were carrying out investigations in the lower reaches of the Danube. But to achieve effective results in improvement of water quality, the efforts of all interested countries had to be coordinated so as to formulate an integrated programme and methodical approach. If this could be achieved, the countries of the Danube basin would be in a position to work out and implement purposeful and satisfactory measures for water quality protection.

3.1.7 Yugoslavia

Mr M. Miloradov enumerated the wide range of tasks required in the protection of water quality, from observation and research, through the implementation of river training works and wastewater treatment facilities, to legislation and economic incentives.

Yugoslavia had been working intensively on such problems for a number of years. Legislation had been enacted, systematic measurement and observation of river water quality organized, specific research on a wide range of relevant topics had been carried out, and projects to prevent the discharge of wastewater into watercourses had been completed.

Water quality was one of the key components of the environment, and it was vital for the problems to receive full attention both at national and at international level.

Pollution control on major international rivers like the Danube was of great importance, and it was to be hoped that the results of the Seminar would further that goal.

3.2 Participants from organizations in attendance

3.2.1 United Nations Development Programme (Mr S. Andersen, Assistant Administrator and Director of European Office, UNDP)

Mr Andersen felt that the results of the project were not just academic but that the Hungarian Government had already begun to put to use some of the important findings on an extended scale and not only in the pilot areas.

It was the greatest encouragement for UNDP when its staff could see that their efforts had a multiplying effect and led to true change - economic and social. He also hoped that the efforts made in Hungary, somewhat similar to the efforts at the national level in other countries along the Danube, would further activities that might be of a more international character. The WHO Regional Director for Europe had, in his opening address, mentioned that the seminar could be considered an opening for collaborative efforts in the continued assessment of the quality of Danube waters so as to provide information for identification by the riparian governments of national and possibly international actions which might be desirable in order to protect and enhance the environmental quality of the Danube and its tributaries. It was not necessary to repeat the several expressions of interest made by governments in such cooperative efforts or reassert the UN system's willingness to respond. There was, in any case, in Europe an increasing tendency towards cooperation in accord with increasing emphasis on the establishment and strengthening of national institutions and activities, especially in the spirit of the Helsinki Conference and its Final Act.

In recognition of the added dimensions to the problem as it appeared at the end of the UNDP/WHO-assisted project, immense benefits might also be derived from such projects for countries outside Europe. Similar activities were under way in Asia, Africa and Latin America. The valuable examples given in the relatively highly developed countries in Europe could often point out institutionally and technically, how to go about such projects in less developed parts of the world. That was particularly true as regards applying the results of the UNDP-sponsored cooperative programme for Europe.

Commenting on the harmonious way in which all bodies associated with the project had worked, in particular the other international institutions, such as the United Nations Economic Commission for Europe and the Environment Programme, he pointed out that it was of course the ultimate responsibility of each country and each government to determine to which degree such problems could be resolved at the national level and to which degree international cooperation was necessary to bring about the desired results.

A number of representatives of international bodies also made statements during the seminar and their remarks are summarized hereunder.

3.2.2 Danube Commission (Dr G. Fekete)

Dr Fekete spoke of the long-standing links between the Danube Commission, an intergovernmental organization and WHO. In 1961, the formulation of hygiene rules for the Danube navigation had begun, and still earlier, in 1957, the Danube Commission had adopted recommendations concerning common phytosanitary and veterinary rules on the Danube, both sets of regulations being drawn up in collaboration with WHO experts.

To prevent the pollution of Danube water by navigation, formal decisions had been taken by the Danube Commission in 1960 prohibiting the discharge from ships of anything that could pollute the water. The decisions had been incorporated in recommendations in 1961 to provide vessels with cleaning facilities and, to establish in the main ports, waste-oil and wastewater receivers. These requirements were laid down in the Fundamental Rules of Navigation on the Danube River.

Pollution and damage caused to the river by navigation were regularly discussed and the subject of damage caused by polluted water to navigation (i.e. to ships, engines and especially to the crew) had recently been given consideration by the XXIVth Congress of the Permanent International Association of Navigational Congresses (PIANC), Leningrad, September 1977. In fact a meeting of experts under the Commission's auspices had just closed, at which the topic had been one of the matters discussed. This was, of course, in conformity with the Final Act of the Conference on Security and Cooperation in Europe, Chapter 5, which dealt with environmental issues, where safeguarding of waters from pollution was mentioned as a very important field of concern to all.

All of those present at the seminar, as people living, had a responsibility for the general living conditions of future generations including the maintenance of clean water, and it was also the duty of those present to assure for navigation and navigators reasonable conditions on navigable waterways everywhere. The worthwhile results obtained in the project could provide a sound basis for developing coordination of activities in monitoring and for evaluating water quality throughout the Danube and on other rivers.

Representatives of the Danube Commission had attended the very important UNDP/WHO seminar on systems analysis in water quality management, in February 1975, and he himself had taken part as a temporary adviser in a WHO Regional Office for Europe Workshop on the study and assessment of the water quality of the Danube in Copenhagen in March 1975. He felt that the two activities as well as the seminar and the active UNDP/WHO-assisted project had served to further the protection of Danube water, human health and interests of navigation.

3.2.3 International Institute for Applied Systems Analysis (Dr M.B. Beck)

Dr Beck, describing the objectives and nature of IIASA's research activities, particularly as regards their relevance to water quality management in the Danube basin, prefaced his remarks by saying that his statement did not necessarily represent the views or opinions of the International Institute for Applied Systems Analysis (IIASA) or of the national member organizations supporting the Institute.

IIASA had been conceived as an institute where scientists and engineers from different nations could work together to solve the many problems now confronting the technically developed countries; it was a non-governmental institution supported by 17 national member organizations; and apart from the USA and the USSR, most of the participating countries were in east or west Europe.

In undertaking research into problems which cut across national boundaries, and acting as a forum for east-west consideration of issues that affect all societies, IIASA was engaged in one area of interest to participants in the seminar, the Resources and Environment Area, led by Professor O. Vasiliev from the Soviet Union, where it had five projects, known in the Institute as tasks:

Task 1 - Regional water management,

Task 2 - Models for environmental quality control and management,

Task 3 - Environmental problems of agriculture,

Task 4 - Regional environmental policy design and management,

Task 5 - Global climate.

Dr Beck's own interests were in the application of system identification and parameter estimation techniques to inland river water quality modelling and control. Others associated with the same task had a very strong fluid mechanics/civil engineering background; attached to it there was a hydrobiochemist from the Soviet Union, for example, and from time to time both sanitary engineers and systems ecologists had visited the Institute and provided additional contributions. Some of the staff were active in model development and application for lake ecosystems (eutrophication) and thermal cooling ponds (also problems of reservoir stratification). One collaborative case study had successfully set out to investigate how best to allocate water for various types of crop production in the Silistra region of Bulgaria. The bulk of the study's work was distributed between the Bulgarian Ministry of Agriculture and Food Industry and a small group of three specialists at IIASA - these three scientists represented three different countries, Bulgaria, New Zealand, and Poland. A second example of collaborative research was the Czechoslovak project for water quantity and quality management in the Ohre River Basin. There, it was hoped to solve some of the technical problems by putting the Ohre River Board in contact with already existing relevant technical expertise at IBM Pisa (Italy) through the good offices of IIASA. And lastly, IIASA was coordinating the production of a monograph on the actual state of water quality modelling.

As regards the Danube, participants in the seminar had heard that under the UNDP/WHO-assisted project a water quality monitoring system had been installed, that a better assessment of present-day pollution of the Danube was available, and that preliminary models and plans had been formulated for the management of water quality in Hungary.

For the future, many problems still had to be solved both at a planning and an operation stage. All too often it was forgotten that the management of environmental impacts was not only a function of building, say, better waste treatment facilities, but also a function of operating the facilities more efficiently once they had been built. The solution of such problems in the Danube basin required above all:

(i) international cooperation;

(ii) an integrated approach, which could deal with all facets of the problem; and

(iii) a multidisciplinary approach.

In so doing, there was scope for <u>applied</u> systems analysis to be used in contributing to an understanding of how we might best husband the qualitative resources of the Danube which was so urgently needed for the future.

3.2.4 <u>International Limnology Society (SIL)</u> (Professor A. Berczik)

Professor Berczik reminded participants of the origins of the International Research Group on the Danube, founded under the auspices of the International Limnology Society in 1956 with the objective of promoting cooperation among hydrobiologists of all riparian countries in the regular and concerted study of the Danube, a professional basis rather than as an intergovernmental activity. The nature of the Research Group had helped work start promptly, kept administrative costs down and assured lively discussions, and in the two decades of its existence had resulted in the publishing of several books, and the presentation of many hundreds of papers and lectures at conferences organized by it. Research activities, results and work so far had been characterized by open-mindedness and a sense of responsibility among all professionals participating in pollution control and water resources development, but had shown up the differences existing between research activities in the various Danube countries. Although the group had succeeded in mobilizing the professionals, in formulating recommendations and in coordinating their activities, it could not resolve the differences in the make-up of professionals from the various countries, the differences in technical facilities, instrumentation and so on. The group's activities had demonstrated the paramount importance of maintaining cooperation among neighbours.

In spite of the difficulties, a comprehensive picture had been obtained during the past two decades on the biological state and principal processes in the Danube, and a professional community had sprung up which understood the state and changes in Danube quality and was rich in experience and capable of dynamic development.

The International Research Group on the Danube had noted with satisfaction the interest and participation of WHO in its meetings and activities; effective cooperation had developed in the countries having WHO Danube projects between the professionals of the project and members of the group. For its part, the group was incorporating in its activities techniques and recommendations suggested by WHO.

4. SUMMARY AND CONCLUSIONS

4.1 <u>Summary</u>

The two pilot zones of the UNDP/WHO-assisted project in Hungary had been carefully chosen. One was a typical reach of main river which had proved to be a good example to demonstrate the long-distance effects of pollution and their impact on the public water supply of a capital city.

The other was a small tributary, the Sajó, not in itself vitally important except for the provision of water to local industry and as a drainage channel for its effluents. It feeds, however, the Tisza which was a much bigger river and an important national water resource, used principally for irrigation purposes. Multidisciplinary teams had been employed in each pilot zone and in the Sajó basin had developed a management plan for the catchment, based on studies of alternative strategies. The limitations on developing the Tisza for irrigation purposes were also known. These were due in large measure to the non-biodegradable pollutants, many of which were transported not in the waterbody itself but in the sediments of the bed of the river.

Similarly, the choice of the section of main river had led to the development of a philosophy which might be applicable to each section of the Danube without having first to engage in long and detailed investigations.

However, no pilot zone could be treated in isolation, because of the many effects from outside the area. Therefore the validity of emphasis on the need to integrate efforts over the whole of the Danube catchment was beyond question.

The first step was to build on the experience gained from the two pilot zones, which had shown how a national water quality management plan could be established from the viewpoints of legislation, surveillance, the abatement of pollution and the relationship between pollution control and physical planning.

However, such a national plan could not be developed without regard to external international factors. The development, both proposed and actually being carried out, in the Danube catchment, was on an enormous scale and included the construction of new navigation channels which would involve the transfer of water between the Danube and other major river basins; large-scale hydroelectric and thermal power station development (including the use of nuclear technology); vast irrigation schemes; greatly increased demands for water, particularly by industry and the great and ever-increasing public interest in the amenity value of open waters.

There was irrefutable evidence that the Danube was facing a crisis which could have untold socioeconomic effects in the years to come.

One of the most serious of the long-term problems was sediment transport with which bioresistant substances such as heavy metals and polycyclic aromatic hydrocarbons could not be dissociated. Both of them had adverse effects on both human health and the ecosystem, but the problem could not be dealt with in isolation as one of pollution control, because it was intimately connected with the hydrological regime of the river and man's distortion of it.

In the Danube, each country through which it flowed had to defend its legitimate interests. Since in any river system there was a conflict between upstream and downstream interests, proper account of this fact had to underpin any endeavour to build a community of interest for the welfare and improvement of the Danube as an international waterway.

4.2 Conclusions

After discussion, participants in the seminar reached the following conclusions:

(1) The River Danube is experiencing the effects of very rapid socioeconomic development. The very great expansion in all Danubian countries of industrial and agricultural production is resulting in rapidly increasing requirements for water supply and the reclamation of used waters. Increasing urbanization also means that increasing supplies of drinking water are required. Most of this will have to come from the Danube and therefore any further deterioration in the water quality may be harmful to human health. To minimize this possibility, international cooperation is required. The river water is being increasingly utilized for both hydroelectric and thermal power production and a number of large barrages are being constructed which will alter its flow regime. Furthermore, a number of connecting channels are envisaged to other river systems for international navigation.

(2) There was general agreement that many of the problems now being faced by the River Danube and its tributaries are of a fundamental nature and decisions now being made will inevitably affect the river regime both in the short term and also over very long periods of time.

(3) Sediment transport, with associated bioresistant substances such as heavy metals and polyaromatic hydrocarbons, is a major long term problem, with potential effects both on human health and the ecosystem.

(4) The presentations by participants from six of the riparian countries confirmed the very large amount of work which is in progress concerning the various water quality problems now being experienced. There was a general view that many of the problems could not be solved within individual countries and that extended cooperation was increasingly becoming necessary. This should build on existing work, both that carried out by the countries themselves, and also in cooperation with international agencies. Participants from several countries emphasized the relevance and value of UNDP/WHO activities such as the Hungarian project in this regard.

(5) The conflicts between upstream and downstream interests are recognized and must be taken fully into account in developing any form of international collaboration.

(6) Data collected in the past are stored in many countries. Some of these would be very useful for the construction of mathematical models. The exchange of these data could be an early step in international cooperation. For such data and future data to be available to all countries, a common format and coding system is required. The conclusions of the Reading Workshop (4 - 14 January 1977) should be taken into account in this regard and the possibility of using common chemical and biological data formats examined.

(7) Statements were presented by the Danube Commission, IIASA and SIL which emphasized the importance of international collaboration concerning the water quality problems of the Danube and the representatives of UNDP and WHO both stressed that their organizations were ready to react to requests from governments in this regard.

PROGRAMME

30 November 1977

(1) Opening of seminar

(2) "Pilot Zones for Water Quality Management in Hungary," presentation of reports on project

(3) Lecture on WHO Workshop on The Optimization of Water Quality Monitoring Networks, Reading, 4 - 14 January 1977

1 December 1977

(1) Continuation of presentation of reports on project

(2) Lecture: "Total River Basin Assessment of Sediment Erosion-Transport-Deposition Processes by Mathematical Model"

(3) Discussion

2 December 1977

(1) Summary by Rapporteur: first two days of Seminar

(2) Statements by participants of the six riparian countries present

(3) Statements by international organizations in attendance

(4) Discussion

(5) Summary and conclusions

LIST OF WORKING DOCUMENTS

General report No. 1

Perspective research and technical development activities of regional water quality management in Hungary, by Dr P. Benedek

Discussion papers

Research and development in the field of water quality control and related topics, by Dr Gy. Kovács

Comments on General Report No. 1, by Drs P. Benedek and F. Papp

General report No. 2

Problems of establishing data collection systems for water quality management and experience for further development, by Mr G. Pinter

Invited lecture

Report on the WHO Workshop on the Optimization of Water Quality Monitoring Networks, by Mr D.H. Newsome

Discussion papers

Information on the bacteriological survey and data (for the Danube), by Dr Zs. Deák

Comments on automatic water quality monitoring, by Dr P. Literáthy

The aim of the instrumentation programme completed within the scope of the project, by Dr I. Hoffman

Reliable data for water quality control, by Dr B. Csermák

Problems and experiences related to data acquisition systems in water quality management, by Mr K. Almás

General report No. 3

Optimization problems of engineering-economic models for water quality management, by Dr G. Bora

Discussion papers

Alternative technologies of wastewater treatment for economic optimization, by Dr Gy. Mucsy

Some remarks on the cost functions used in the pilot zone modelling, by Dr G. Réczey

Some methodological aspects of optimization techniques, by Mr J. Pinter

General report No. 4

Descriptive dispersion model for the River Danube - An approach to water quality assessment of large rivers, by Dr L. Somlyody

Discussion papers

Comments on dispersion modelling described in General Report No. 4, by Dr Ö. Starosolszky

Contribution to the cross section studies on the Danube, by Mrs M. Puskás

Problems in assessing the pollution load in the Danube, by Mrs M. Ábráham

Hydrological problems related to the Gabcikovo-Nagymaros Hydro-Electric Project, by Mr I. Matrai

General report No. 5

Supplementary studies needed for assessment of water quality bioresistant materials, bottom sediments, etc., by Dr P. Literáthy

Invited lecture

Total river basin assessment of sediment erosion-transport-deposition processes by mathematical model, by Dr G. Fleming

Discussion papers

Analytical problems of bottom sediment investigations, by Mr F. László

Water pollution problems caused by the Gabcikovo-Nagymaros barrage system, by Dr P. Benedek

General report No. 6

Development of legislative methods for water quality management in Hungary, by Dr A. Hommonay

Discussion papers

New approach to system of incentives in water quality management, by Mr E. Katona

Behaviour control and environment protection, by Dr P. Pásztó

General report No. 7

Introduction of water quality models as a tool for decision-making in Hungary, by Mr B. Hock

Discussion papers

Problems in regional water quality management, by Mr L. Balázs

Modelling the mixing process in the River Sajó, by Dr G. Jolánkai

Study on the assimilating capacity of the River Sajó and the mathematical model of total dissolved substances, by Dr Á. Fázold.

Regional planning, by Mr K. Röszler

Other documents presented

Experience gained in Czechoslovakia in UNDP/WHO project on evaluation of water quality in the River Danube, by Dr I. Fratric

Some results of research on water quality, dispersion characteristics and sediment transport in the Yugoslav sector of the River Danube, by Mr M. Miloradov

LIST OF PARTICIPANTS

Austria

Dr K. Megay, Advisory Hygienist, Linz

Czechoslovakia

Mr R. Chrast, Deputy Director, Czechoslovak Centre for the Environment, Bratislava
Mr J. Habrovsky, Czechoslovak Centre for the Environment, Bratislava

Hungary

Mrs M. Ábrahám, District Water Authority, Gyór
Mr L. Áll, National Water Authority, Budapest
Mr K. Almás, Water Management Institute, Budapest
Mr I. Árkai, Water Management Institute, Budapest
Dr I. Árvai, National Authority for Environmental Protection, Budapest
Mr L. Balázs, District Water Authority, Miskolc
Dr B. Csermák, Water Management Instituto, Budapest
Mr K. Csontos, National Water Authority, Budapest
Dr Zs. Deák, National Institute for Hygiene, Budapest
Dr Á. Fázold, District Water Authority, Miskolc
Mr T. Fritsch, Water Management Institute, Budapest
Mr S. Gerda, National Water Authority, Budapest
Mr I. Hoffman, Research Centre for Water Resources Development, Budapest
Dr Gy. Illés, National Water Authority, Budapest
Mr G. Jolánkai, Research Centre for Water Resources Development, Budapest
Mr E. Katona, National Water Authority, Budapest
Mr P. Karkus, Water Management Institute, Budapest
Mr R. Kaurek, District Water Authority, Pécs
Mr L. Kelemen, National Water Authority, Budapest
Mr Kontra, Ministry for Foreign Affairs, Budapest
Dr Gy. Kovács, National Water Authority, Budapest
Mr T. Krempels, Institute for Hydraulic Planning, Budapest
Mr F. László, Research Centre for Water Resources Development, Budapest
Mr I. Magó, Institute for Hydraulic Planning, Budapest
Mr Gy. Mucsy, Research Centre for Water Resources Development, Budapest
Dr R. Muts, Water Management Institute, Budapest
Mr J. Novoszáth, National Commission for Technical Development, Budapest
Dr F. Papp, National Water Authority, Budapest
Dr P. Pásztó, Water Management Institute, Budapest
Mr J. Pintér, Karl Marx University of Economics, Budapest
Mrs M. Puskás, District Water Authority, Budapest
Mr K. Röszler, Water Management Institute, Budapest
Mr Simor, District Water Authority, Baja
Dr Ö. Starosolszky, Research Centre for Water Resources Development, Budapest (Chairman)
Dr K. Stelczer, Research Centre for Water Resources Development, Budapest
Mr J. Tóth, District Water Authority, Szekesfeherva
Mr L. Tóth, National Water Authority, Budapest

Hungary (continued)

Mr N. Várday, District Water Authority, Gyor

Mr P. Varga, District Water Authority, Budapest

Mr Á. Virágh, National Water Authority, Budapest

Poland

Mrs A.B. Stoch, Environmental Pollution Abatement Centre, Katowice

Temporary advisers

Dr P. Benedek, Head, Institute for Water Pollution Control, Research Centre for Water Resources Development, Budapest, Hungary

Professor G. Bora, Karl Marx University of Economics, Budapest, Hungary

Dr G. Fleming, Senior Lecturer, Department of Civil Engineering, The University of Strathclyde, Glasgow, United Kingdom

Dr I. Fratric, Director, Czechoslovak Centre for the Environment, Bratislava, Czechoslovakia

Mr B. Hock, Senior Research Worker, Institute for Water Pollution Control, Research Centre for Water Resources Development, Budapest, Hungary

Dr A. Hommonay, Senior Research Worker, Institute for Water Pollution Control, Research Centre for Water Resources Development, Budapest, Hungary

Dr P.I. Khalitov, Deputy Chief, Sanitary Epidemiological Department RSFSR, Ministry of Health of the USSR, Moscow, USSR

Dr P. Kothé, Government Director, Federal Office for Water Studies, Koblenz, Federal Republic of Germany

Dr P. Literáthy, Deputy Head, Institute for Water Pollution Control, Research Centre for Water Resources Development, Budapest, Hungary

Mr I. Matrai, Technical Adviser, Water Management Institute, Budapest, Hungary (Co-Rapporteur)

Mr M. Miloradov, Director, Jaroslav Cerni Institute for Water Management, Belgrade, Yugoslavia

Mr D.H. Newsome, Director, Department of the Environment, Water Data Unit, Reading, United Kingdom (Rapporteur)

Mr G. Pinter, Head of Department, Institute for Water Pollution Control, Research Centre for Water Resources Development, Budapest, Hungary

Mr J.E.M. Sas-Hubicki, Federal Institute for Water Quality, Kaisermuhlen, Vienna, Austria

Mr B. Skowyrski, Director, Department of Water Improvement Economics, Ministry of Agriculture, Warsaw, Poland

Dr L. Somlyody, Senior Research Worker, Institute for Water Pollution Control, Research Centre for Water Resources Development, Budapest, Hungary

Representatives of other organizations

Danube Commission

Dr G. Fekete, Director, Budapest, Hungary

Mr A. Afanassiev, Adviser on hydrometeorological matters, Budapest, Hungary

Economic Commission for Europe of the United Nations

Mr G. de Bellis, Environment and Human Settlements Division, Geneva, Switzerland

International Institute for Applied Systems Analysis

Dr M.B. Beck, Research Scholar, Laxenburg, Austria

International Limnology Society

Professor A. Berczik, Director, Danube International Research Group, Göd, Hungary

United Nations Environmental Programme

Mr G. Biryukov, Senior Programme Officer, Geneva, Switzerland

United Nations Development Programme

Mr S. Andersen, Assistant Administrator and Director, European Office, Geneva, Switzerland

Mr A. Persson, Programme Officer, European Office, Geneva, Switzerland

World Health Organization

Regional Office for Europe

Dr L.A. Kaprio, Regional Director

Mr T. Murawski, Promotion of Environmental Health

Mr J.I. Waddington, Chief, Promotion of Environmental Health