20.02.1994

ENVIRONMENTAL PROBLEMS

Situation prior to the 1977 Treaty*

The Governments of the two countries concluded an interstate treaty in 1977 on the implementation of the Bős-Nagymaros Barrage System. It took years to get to the completion of the final version of the plans. Hence it seems correct to state that views of the early 70s characterize the conception of this project. The following traits were characteristic of this period:

- Subsequently to the second oil-price explosion which set in unexpectedly in 1973-74, interest in new sources of energy greatly increased. Renewable energies became more esteemed, hence the utilization of hydro-power seemed to have a perspective.

- Environment protection as a new economic and social trend and movement was still in its infancy in these years. Society was hardly sensitive to environ-

*In full: Treaty Concluded between the People's Republic of Hungary and the Socialist Republic of Czechoslovakia on the Construction and Joint Operation of the Gabcikovo-Nagymaros Barrage System, Signed in Budapest on 16 September 1977.

mental problems. The legal regulation system of environment protection was underdeveloped. Higher-level resolutions did not make it obligatory to assess environmental impacts prior to a construction.

The dominant approach among technical experts was that though environmental hazards were possible, the unwanted negative effects could either be eliminated through proper technological procedures and well chosen system of operation or at least be reduced to a satisfactory degree in the course of construction or after it. It was held that the possible damage would be far less than the expectable profit.

Hungarian society was very insufficiently informed about the planned construction in the second half of the 70s. The centrally controlled propaganda emphasized only the expectable positive effects: cheap energy will be produced in an environmentally safe way, the proper depth of water recommended by the Danube Commission can be secured for navigation, and also flood control will be safer.

The possible negative effects were either not mentioned at all or only in a simplified form, which thus by-passed the risks. Critical views (like e.g. articles by János Vargha) published in the late 70s and the early 80s were restricted administratively.

No cost-benefit analysis was allowed to be made either in the planning stage or as a result of the growing criticisms following the conclusion of the 1977 Treaty.

The growing criticism of the scientific circles

There were no open scientific discussions on the conception and designs of this construction in the 70s. To establish their work, the designers had ordered several dozens of background studies to be written by researchers and university teachers. Most of these, however, dealt with individual issues. No comprehensive system analyses of the risks were made.

The first worries and reservations in the scientific circles concerning the possible environmental hazards appeared around 1979-1981. News about them got to the Science Policy Committee of the Government, which resulted in resolutions to commission an expert group to examine - in 1982 - the expectable environmental hazards emanating from the given technological implementation. The commission related to the "given technological implementation", that is, politics limited the examinations, and such changes like e.g. the rejection of peak power production could not be imagined. The commissioned report had been completed by April 30, 1983.

The report stated that after 1975 about 60 studies had been written on the expectable environmental hazards and their consequences. However, these were not discussed in a wider circle of experts. Neither these studies, nor the examinations of the past few years gave unambiguous answers to the disputed issues which arose between hydrologists and ecologists concerning the expectable environmental consequences of the Gabcikovo-Nagymaros Project. The lack of complex studies assessing the environmental impacts was partly the cause, partly the effect of the clashes of opinions. Thus the report proposed to have such a study mado in two years' time.

The National Water Authority was assigned to coordinate this project. The study became completed, but was primarily written by people who were interested in the implementation of the project. The conclusion of this study assessing the environmental impacts was that through additional investments, proper technological procedures and correct operation of the barrage system, the environmental hazards can be prevented or be reduced to an acceptable degree. The preconception of the study assessing the environmental impacts is clearly indicated by the surface and underground waters having been mentioned only in a few sentences, stating that significant problems in this area cannot be expected. Ecologists did not hold these statements satisfactory and well founded. Since 1985, the date when the study assessing the environmental impacts was made public, a permanent debate has been carried on between the various expert groups about the expectable environmental consequences.

In December 1983 the Presidium of the Hungarian Academy of Sciences discussed the situation of the Gabcikovo-Nagymaros Project. There were two core issues in this discussion, namely, what will be the long-term environmental risks involved in this investment, and what economic advantages can be expected and how do they relate to the costs. As a result of the discussion, the Presidium took a very reserved stand. Namely, it stated that based on economic and environmental considerations, the right attitude would be either to suspend or to postpone the investment for a longer time.

To make the picture complete, it should also be told that there were also several scientists who - though with lesser or greater reservations - did support the idea of this investment. Those who opposed it belonged to different branches of science, the most critical ones having been the ecologists and the economists.

Periods of the events of the last 15 years

The history of the Bös-Nagymaros Barrage System after the conclusion of the Treaty, the preparation of which lasted for about two decades, can be divided into four characteristic periods.

1. From 1977 to May 1989 when the investment was started, and carried out with changing intensity.

2. From May 1989 to May 1992 when the Hungarian party suspended the construction, while the Slovak party continued it.

3. From May 1992 to October 1992, which started with the termination of the 1977 Treaty by the Hungarian party and ended with the diversion of the Danube - a one-sided step - by the Slovak party.

4. Since 24th October 1992, the date of the diversion of the Danube.

We are giving here a possible classification of the environmental impacts:

a. Effects - advantageous or disadvantageous - which had already been presupposed in the original plans and to the minimization of the disadvantageous ones of which there had been measures planned.

b. Factual damage which could not be foreseen but has become clear by now.

c. Future damages which are now already sure to happen.

d. Risks which are highly probable to occur.

We have examined the following fields from the aspect of environmental impacts:

- earth sciences,
- soil resources,
- surface waters,
- underground waters,
- agriculture,
- forestry,
- fish biology, fishing,
- nature conservation,
- public health.

We are summarizing below the most important elements of knowledge related to the various periods, the various types of environmental impacts and the individual factors.

The period from 1977 to May 1989

As we have already mentioned, disadvantageous environmental impacts had already been considered in the course of planning, however, these were limited. The greatest danger was considered to be likely in changes in the water table balance, but it was thought that additional procedures, like for example systems of seepage canals, could counterbalance the negative effects. The investors painted a calming picture for the state leadership, and the modest information provided for society arouse the same feelings.

The following statements can be made in connection with the individual factors:

Geology

From the point of view of geology, the greatest risk has been the lack of detailed knowledge of the area; under such circumstances, a number of preparatory and planning tasks (e.g. environmental impact assessment, technical planning) cannot reach well-founded results. Safe prognoses can only be made on the basis of systematic studies revealing the geological background conditions.

The planning of the Danube dams was not preceded by a detailed geological survey of the region. It was a serious mistake that there were no structure-exploring deep drillings in the impact area of the dams. It well demonstrates the insufficiencies of planning that the contractors did not even have the necessary permit of the geological authorities.

It is a further problem that the research results obtained separately in Hungary and the Czech and the Slovak Republic have never been integrated. For example, the so-called Gabcikovo fault line discovered in the territory of Slovakia has not been traced further in Hungary. This fault was the reason why the site of the Gabcikovo dam was changed in the early 70s, although by not more than 600 metres with respect to the original plan. Thus, as is admitted by some Slovak experts, this dam has been built in the neighbourhood of a geologically young fault.

The most important element of the deep structure in the impact area of the Gabcikovo dam is the Rába line, the border of the Alpine and the Transdanubian tectonic units. Its position is highly uncertain, at present it can be traced in two alternative variants. Structural exploration by means of drillings in the young sediment has not been carried out; satellite photos which may be interpreted in several possible ways do not allow to form a unanimous and profound opinion. Consequently, a clear structural view cannot be constructed yet.

Another set of problems concerns the seismology of the area of the Bös-Nagymaros Barrage System. The seismicity values of the Joint Agreed Plan cannot be accepted; the seismicity problem cannot be answered with a reliability required by international norms, since the necessary studies are lacking. The seriousness of the problem is shown by the fact that the expected intensity estimated for the Dunakiliti area on the basis of historical earthquakes is 8.7-9.0 MSK at the usual security threshold, while the original plans were prepared by assuming 6.0 MCS.

From among the uncertainties of planning, the sizing of the embankment is an especially grave problem, owing again to insufficiencies of prior investigations. The weakest point of the Dunakiliti reservoir is the embankment: it is the largest structure regarding its volume, while at the same time it is the most heterogeneous in its structural constitution, material and quality. The stability of certain parts of the embankment cannot be considered safe against earthquakes that are likely here. This especially applies to the stability of the bank higher than 7 metres, as they are not sufficiently safe against sliding. Security tests along the Dunakiliti reservoir show that the safety characteristics of the embankment do not fit the international standards. The risk level taken into consideration in the plans actually applies to common buildings where environmental effects can be excluded.

Soil resources

The original plan reckoned with significant changes in the water table balance and the substance regime of soils in the affected areas after the system has been put into operation. Depending on changes in the water table balance, the following four basic cases were prognosticated by the designers.

1. Groundwater is in the gravel layer and its changes will remain therein. In these areas (i.e. about 30% of the total territory, primarily in the north-western part of Szigetköz), there will be no changes in the water table balance.

2. Groundwater is in the fine topsoil and its changes will remain therein. In these areas (about 30% of the total territory, primarily in the lower lying areas and in the south-eastern part of Szigetköz), it is prognosticated that

(a) a rise (of 20%) in the groundwater level will be followed by a little increase (<50 mm/year) of the capillary water supply originating thereof;

(b) a (10%) fall in the groundwater level will be followed by a small (<50 mm/year) decrease of the capillary water supply.

3. Groundwater is in the fine topsoil, but as a result of the operation of the barrage system, it will go down into the underlying gravel layer. (This means about 30% of the total territory, primarily the north-western part of Szigetköz, from Ásványráró to the country border.) In these areas, the about 100-150 mm/year capillary water supply will completely cease to exist, greatly increasing the territory's sensitivity to droughts, with all its negative consequences for the natural and agro-ecosystems.

4. Groundwater is in the underlying gravel layer, but as a result of the operation of the barrage system, it will rise into the fine topsoil. In these areas (about 10% of the total territory, primarily the area south-east to Ásványráró), we have a situation opposite to the one described above.

These changes in the water table balance will also change the substance regime of the soil. The following important changes can be prognosticated:

(a) Formation of lime accumulation layers, petrocalcic horizons, limestone pads at the edge surface of the underlying gravel layer and the fine topsoil, as a consequence of the effect of groundwater containing much carbonate. This will make the soil become of a shallow depth and also become sensitive to droughts.

(b) In areas of sinking groundwater levels, the soil's sensitivity to droughts will increase, crop yield security will decrease and become more dependent on precipitation; decomposition of organic matter and the leaching out of nutrients will increase, while the hydromorphic characteristics of the soil, its moisture content will decrease.

(c) In areas with rising groundwater levels, the danger of inland waters will increase, and overmoisturing will lead to detrimental anaerobic processes. The probability of the formation of limestone pads, which make the topsoil shallow, will become higher; moreover, in undrainable, lower lying areas, alkalization and salt accumulation processes might occur. The probability of the latter is not significant in those areas of Szigetköz which has good natural drainage conditions, but on the Slovakian side, especially east to the middle of Csallóköz, it means a serious environmental hazard.

(d) If the groundwater becomes polluted from various sources, the accumulated pollutants might get into the plant-animal-human being nutrient chain through the soil, thus causing direct health hazards.

The original plan intended to prevent the prognosticated detrimental effects by constructing seepage and draining canal systems. However, their water demand and costs were greatly underestimated in the plans. Their absolute necessity was clearly proven by the drought in 1992, by the low water level of the Danube due to natural causes, and by the drastic decrease in the groundwater level as a consequence of the construction of Variant C (together with its already manifesting ecological effects).

Surface waters

In case of the implementation of the original plan, the eutrophication process - resulting from the slowing down of the velocity of water due to damming up and from the several days' long cycle of the exchange of water in the reservoir - would have been much faster and had more deleterious effects than originally expected. The prevailing idea was that by changing the mode of operation of the reservoir and building additional objects which would change the flow conditions, no harmful processes would develop or they would be so minimal that they would not cause any trouble. This optimistic view could hardly be supported by anything.

It is highly probable that the nutrition content of the sediment accumulating in the reservoir over the years would have raised the degree of eutrophication. This would have worsened the quality of surface waters especially in the warm summer periods in dry years. This process would have had its greatest effects on Hungarian territory, i.e. the detrimental effects would have primarily affected this area.

The sediment accumulating in the reservoir, the dynamism of its heavy metal content, its sudden and intensive appearance, would also have deteriorated the quality of surface waters. Besides the advantageous self-purification processes taking place in the reservoir, a significant growth of algas must also be reckoned with, which - when getting into the lower sections of the river - might lead to a problematic load of organic matter.

Underground waters

In Szigetköz and its adjoining territories, the valuable and good quality underground water stock which is stored and moves in the gravelly alluvial fan of the Danube would have been detrimentally affected by the barrage system.

The fine sediment accumulating in the Dunakiliti reservoir, the possible toxic materials contained in it might have worsened the quality of underground waters through the reduction processes that happen in the course of seeping through the sediment. (Earlier the underground waters were supplied directly from the main branch of the Danube with good quality water.) The deterioration of quality of the underground waters would have occurred in a significant part of the several hundred metre thick gavel complex in a few years or decades. The original plan did not reckon with the pollution of the significant potential drinking water reserve of Szigetköz-Csallóköz, estimated to be about 10 km^3. The capacity of this potential water reserve is estimated to be 0.5-1.0 million m^3/day on the Hungarian side.

In the case of the artificial recharge systems planned for later years on the protected side and in the side-branch system of the flood-plain, the deterioration of the quality of water is also imminent.

In the vicinity of the reservoir a rise in the groundwater level was reckoned with, and the surplus water was planned to be drained through seeping canals. With the progress of kolmatation, infiltration would have decreased both from the reservoir and in the case of the water supply systems. This could have been helped by dredging, which, however, raises newer water quality problems.

In the old Danube bed, letting 50-200 m^3/s water run in it, the planned bottom dykes - owing to the little amount of water dammed up - would have increased kolmatation and, as a consequence, also the risk of the deterioration of water quality in case the Danube's water seeps into the groundwater.

Along the river section below the Dunakiliti dam, a 3-4 metre decrease in the groundwater level was calculated (lessening towards the Moson branch of the Danube), which could have been eased through the planned additional water supply and the bottom dykes. The most significant decrease would have occurred on the flood-plain below Dunakiliti and in Central Szigetköz. In many places the water supply from below of the fine topsoil would have ceased; in years of drought this supplements precipitation. Irrigation was planned in these areas, but even so, decay of part of the alluvial forests had to be reckoned with.

In the eastern part of Szigetköz - where the quality of underground waters is less favourable - no essential changes had been expected.

In the dammed up section between Gönyü and Nagymaros, silt deposition had to be reckoned with owing to the lower velocity of the water, especially in the section below Nyergesújfalu. Silt deposition and the reduction processes developing in it, the possible toxic sediments would have threatened the bank filtrated water stocks along this section, which would have added to the water quality problem already present in this area.

The karst water reservoir of the Transdanubian Central Mountains is in direct hydraulic connection with the Danube bed at Dunaalmás and Esztergom. The risk of the Danube water's seeping into the karst water reservoir, the pressure in which decreased due to mine-drainage, is present even without damming up; however, damming up would have increased this risk in case the depression of the karst system remains.

Below Nagymaros it was primarily the bank filtrated water stock of the Budapest Municipal Waterworks at Szentendre Island that was threatened by the downstream effects of the Nagymaros damming up. Dredgings planned in connection with the construction of the barrage system, but serving also industrial purposes, reduced the yields of the bank filtrated drinking water resources, which secure a greater part of the supply of Budapest, by about 25%. In the downstream sections of the Nagymaros dam, the minor erosion and the insecure silt deposition would have meant inadmissible risks to the bank filtrated system which is anyway sensitive owing to the reasons given above and in which most of the natural filtering process is taking place in the few centimetre thick upper layer of the river-bed.

Agriculture

Intensive agricultural production is carried out in this region. The crop yields of the major plants (wheat, maize, sugar beet, spring barley, fodder maize) were about 15-20% higher here than the national averages. Plant growing is primarily based on the utilization of natural precipitation which is supplemented in an advantageous way by groundwaters. Irrigation is usually not economical due to its high costs and is thus only applied in the case of plants of great value (sugar beet, vegetable crops, etc.). The ratio of irrigated territories in Hungarian agriculture is about 4-5%, in Szigetköz it is minimum 8-13%.

The original plan reckoned with the disadvantageous effects along the Old Danube, caused by the diversion of 90-95% of the river's water into the power canal.

Forestry

The alluvial forests, primarily poplars, represent a great economic value. This area constitutes one of the important raw material resources of cellulose production. Beside the forests for industrial utilization, the ecosystems of the indigenous species of the alluvial forests, which characterize this area, also occupy a significant territory. Changes in the groundwater table would have influenced both the wood volume growth and the yield in value of all the forests in a disadvantageous way. Species requiring less water could have been planted instead, but both their biomass production and the value of their yields per year would have been significantly less than those of the present species.

In the course of construction, 1200 hectares of high-yielding alluvial forests were cleared on Hungarian territory, while in Slovakia 3180 hectares of similarly valuable woods had to be cleared. It seems justified to suppose that had the barrage system been built according to the original plans, much more - at least a further 3500 hectares of - alluvial forests (on the flood-plain and the protected side) would have decayed and died out in 5-15 years than was originally reckoned with. That is, about half of the forests of

Szigetköz would have become victim of the construction and operation of the barrage system.

Fish biology - fishing

As a consequence of the work done at the Dunakiliti reservoir, the flood-plain section of Szigetköz from Rajka to Dunakiliti was practically abolished, which entailed a proportionate decrease in the fish population of the area. The water level fluctuation due to the originally planned peak power production would have caused serious troubles in the daily life-cycle of fish. In spawning season, this would have either prevented the fish in the area along the bank from spawning (pike, carp, most of the bream species, etc.), or millions of roes would have got on dry territory and thus perished. Peak power operation would have had its effect on an over 100 kilometre long section of the Danube, together with the mouth sections of the affluents (the Rába, the Moson branch of the Danube, the Garam, Rábca, Lajta and Ipoly rivers) on a water area of about 140 kilometres.

The Szigetköz section of the Danube is the most important spawning and fry breeding area of the Danube in the Carpathian Basin; in the case of some migrating fish (e.g. *Vimba vimba*), the reproduction effect of the area covers several hundred kilometres.

Pęak power operation, by way of the faster passing of floodwaves, would have caused reproduction problems in the affected areas. In the case of fish species spawning in the side branches, there would have been no possibility for spawning (which is dependent on very strict physico-chemical parameters), for the hatching of the roes and the development of the fries, owing to the shorter flood period of the flood-plains. This means an especial hazard for the protected and endangered species, in the case of which no man-made stocking can take place.

Reproduction problems would have entailed serious losses in both nature protection values and in fishing performance. As a result of the water kept in the reservoir, the Danube loses its sub-mountain character, which entails the transformation of the fish population, leading necessarily to a degradation in natural values. Although a significant decrease in the stock of fish was reckoned with in the original plan, its impacts on fishing, nature conservation and ecology were greatly simplified.

To sum up, implementation of the original plan would have been detrimental in respect of both fish biology and fishing.

Nature conservation

The territorial situation of Szigetköz, its geological, geomorphological, climatic and hydrographic properties, the mosaic-like arrangement of biota in it, provide living conditions for a variety of species and ecosystems. The flora of higher plants of the area is well known; it has 900 species, which means more than one third of this flora in Hungary. There are 67 plant communities known in Szigetköz (2 relicts, 10 protected, 25 semi-natural, 6 pioneer, 6 disturbance resistant, and 18 weed communities). There are 60 protected plant species in this area.

Between 30 and 80 per cent of the animal species living in Hungary can be found here. For example, 116 species of mollusks live in the area, meaning 48 per cent of the Hungarian fauna. There are 96 species of crabs known in Szigetköz, which means two thirds of the Hungarian fauna. 50% of the of dragon-fly species known in Hungary can be found here. Out of the 80 species of fish in Hungary, 65 live in the waters of Szigetköz. 57% of the Hungarian bird fauna, i.e. 206 species, can be seen in this area. The number of protected animal species living here is about 300. Some remnants of alluvial forests, the mortlake of Lipót and the marshland of Arak are specially protected nature conservation areas.

Those who made the original plans were not sensitive to nature conservation. The dominance of the one-sided economic interests (e.g. gaining energy, improving the navigation conditions) was so strong that they paid practically no attention to the conservation of natural values.

The ecosystems in Szigetköz are still in a natural or almost natural condition and they occupy a significant area of the flood-plain and the territory on the protected side outside the flood-plain. These ecosystems have accustomed themselves to the centuries-long dynamics of the river. In the continuously changing side branch system of Szigetköz, the ecosystems can slowly follow the processes taking place (this is called: coenological succession). In the case of forests, the process is slower, it can only be measured on a scale of centuries. If there are quick, drastic changes, the answer is degradation and decay. It would take the nearly natural forests several centuries to recover even if there were advantageous conditions.

The original plan would have essentially sacrificed the existing ecosystems of Szigetköz and would have thus drastically decreased the biological values of this region.

Public health

Damming back, in line with the original investment plan, would have resulted in a different situation in respect of the self-purification of the sewage getting into the Danube from the settlements along the river. The construction of sewage treatment plants - involved in the original plan - would have solved the majority of the problems, but, most probably, this would not have been realized in time, owing to the lack of resources. Changes in the water table in areas without a sewerage system would have greatly affected groundwater pollution resulting from the use of cesspools. A decrease in the water table would have improved self-purification in the soil, whereas an increase in the water table would have deteriorated it.

By raising the groundwater level, damming up would have caused significant deterioration in the bank filtrated waters in the upstream area, for example, at Dömös and Esztergom in the case of Nagymaros. As a result of the reduction effect, manganese, iron, ammonium would have appeared in the waters, which would have necessitated the application of new purification technologies.

Increasing eutrophication, as a result of the proliferation of algas and masses of cells owing to the slowing down of the velocity of the river, would have entailed an increase of the by-products due to chlorination in the purified surface waters (namely, in the case of Lábatlan and Budapest). As the majority of these compounds are mutagenic, some of them carcinogenic, water purification technologies should have been improved considerably to prevent the health hazards.

The lower velocity of the river and the eutrophication process would have improved the quality of water in the Danube from a bacteriological point of view, so the risk of contamination in case of bathing (which is today a real risk even in the section above Budapest) would have decreased.

The period from May 1989 to May 1992

Owing to the risks shown by analyses and environmental impact assessments, the Hungarian party suspended construction in this period, while the Slovak party continued it on its own territory. From the point of view of additional environmental hazards, this period is indifferent. No new dangers or risks were involved in the Slovak construction, that is, nothing new compared to the original plans had emerged.

Earthquake

Intensive professional discussions commenced in 1989-1990, ending in the conclusion that the planned investment had not been studied properly from the geological and seismological points of view, and this lack of information might mean serious risks.

In 1991-1992 there were possibilities to make detailed and comprehensive analyses in some fields (e.g. in that of seismic risks). These examinations led to the conclusion that the basic seismological data used in the course of planning were not correct, the value of the expectable effect (horizontal acceleration) of an earthquake in this territory would be about 5-10 times higher than reckoned with in the plan.

The period from May 1992 to October 1992

This period started with the termination of the 1977 Treaty by the Hungarian party and ended with the diversion of the Danube by the Slovak party. Neither in this period were there any new developments in respect of environmental hazards. The extra warm and dry (droughty) summer of that year and the consequently low water levels in the catchment area of the Danube above Szigetköz practically prognosticated the expectable consequences of a possible diversion of the Danube - even if not in a quantitative, but in a qualitative respect (i.e. in respect of the kinds of damage). As a result of the Slovak construction, damaging the landscape in the area continued. However, these activities had no direct effect on natural resources and on nature conservation values on the Hungarian side.

The period after 24th October 1992

The Slovak party diverted the Danube. Except for floods, only 150-350 m^3/sec water reached the old river-bed. This caused drastic changes in the hydrological conditions of the area. The reservoir became filled up to about two thirds of its originally planned surface, the turbines of the power plant started to work, the navigation route was diverted. It was primarily the following impacts that could be felt after half a year:

Surface waters

After the diversion of the Danube at Dunacsúny, instead of the earlier about 2000 m^3 water per second, some 150-300 m^3/s was let into the former mainstream bed, except for the flood periods. At Rajka, the reduced water flow caused an immediate over two metre fall in the water level of the mainstream of the Danube, whereas compared to the average conditions, it meant a decrease of four metres. Above Szap, where the downstream canal flows back into the river, damming back showed different values depending on the amount of water diverted toward Gabcikovo. The discharge and the water level of the Danube in this section have greatly changed: except for the dammed back section, lasting low water level is characteristic with slight fluctuations. The fluctuations become great in flood periods for a short while. At the outlet of the downstream canal, also great daily fluctuations have been noticed, depending on the operation of the reservoir.

After the diversion of the Danube, the otherwise little water in the side-branch system of Szigetköz has completely disappeared in most parts of the area in autumn. In spring and summer, the earlier high water levels were missing, which had had the function of supplying the side-branch system by way of the spillovers also from above. In August 1993 part of the water in the Moson branch of the Danube was used to supply some - about 10 m^3/s - additional water into the side-branch system. This could only slightly alleviate the damage. Since spring 1993 the artificial recharge system on the protected side has received about 5 m^3/s additional water supply from the same source.

Occasionally oxygen supply significantly decreased in the water originating mostly from the reservoir and let, as an additional amount, into the Moson branch of the Danube. Between late summer and early autumn of 1993, water quality in the side-branch system was better in some places than in the previous years, owing to recharging.

Underground waters

As regards underground waters, changes so far could only be measured in the water tables. We are going to express the changes with the difference between the water levels earlier and now at the Danube section where it arrives on Hungarian territory after Bratislava (Pozsony).

As a consequence of the dammed up water level at the reservoir at Dunacsúny, at the western end of

Szigetköz (i.e. near the reservoir) the water table rose about 0.5-1 metre. Along the mainstream of the Danube, where the water level became lower, the water table decreased by about 3-4 metres. Farther away from the Danube, the decrease is more moderate, on the average it is about 1 metre along the whole section with lower water level. On the flood-plain, the decrease in the water table usually exceeded 1 metre, while on the protected side, it was smaller than this on the average. In this respect, we also have to take into account that the already mentioned recharging on both the protected side and the flood-plain reduced the decrease of the water table by about 1 metre as compared to the originally envisaged one. Moisturing of the fine topsoil failed to occur - compared to the earlier situation - on a great part of the flood-plain and on some parts of Central Szigetköz.

There were no significant changes expected - neither noticed - in the quality of the underground waters in the examined period. As a consequence of the mentioned decreases of different degrees in the water table, the changed place of the additional supply as well as artificial recharging, the flow directions of the underground waters have changed significantly. Earlier the underground waters generally moved from the Danube towards the Moson branch of the Danube (and even over it). Now they move in a north-west to south-east direction, i.e. more or less parallel with the Danube, in most parts of Szigetköz. The water seeping in the additional supply systems seeps into the Danube bed which has a lower water level now. Also here is seeping most of the underground water of unknown quality originating from the Dunacsúny reservoir.

Agriculture

There was drought in Hungary all over the country in 1993. In the first half of the year there was exceptionally little precipitation. In April and May 1993 there was very little precipitation also in Szigetköz, which from 22nd April was coupled with lasting warm weather. In June precipitation was very different in the various territories of the region, but on the whole it was little and the moisture content of the soil became minimal. The rainfall in July (varying by territories between 48.6 and 102 mm) improved the yields of plants to be harvested in autumn. In each part of the vegetation period precipitation was less than the average of the former seven years. (During the 1993 vegetation period, the rainfall was lower at Mosonmagyaróvár by 87 mm and at Györ by 118 mm than the average of the last 40 years.)

There were significant differences in the quantity of precipitation in the various parts of the region during the vegetation period. (For instance, at Rajka in Upper Szigetköz 240 mm, at Ásványráró in Central Szigetköz 286 mm and at Györ-Bácsa in Lower Szigetköz 153 mm were registered.)

The decrease of the water table came in addition to this situation. There was a significant decrease from Tejfaluszíget to Ásványráró, due to the diversion of the Danube. On a territory of 1900 hectares of arable land previously characterized by a high level of groundwater, the water level decreased by 100-150 cm on the average during the vegetation period. On a further 2100 hectares of land, the level of groundwater decreased by 60-100 cm compared to the previous level. On these territories, the level of groundwater used to fluctuate permanently or occasionally in the top layer, whereas with the mentioned decrease it moved into the gravel layer and thus ceased to function as a moisture supplier. (According to measurements made in March, 20-50 mm were lacking out of the useful water content of the soil of 150 cm on these territories, due to the lack of groundwater supply.)

In 1993 the yields of crops lagged behind the average of the region.

Data on the most significant crops of Szigetköz are as follows:

	Area ha	Yields t/ha	average of the last 13 years, t/ha	difference (%)
Wheat	6118	3.98	5.50	-27.6
Spring barley	1772	3.25	5.06	-35.8
Maize	3631	5.24	6.75	-22.4
Fodder maize	1420	26.72	26.72	-
Sugar beet	1734	37.82	40.68	-7.0

The loss of yields in the case of 11 species having been analysed amounted to 20.5%. The decrease in yields was primarily caused by water deficiency. Half of the yield decline in Szigetköz was due to the scarcity of precipitation, while one quarter could be attributed to the decrease in the groundwater level.

Both the natural endowments and the level of production differ from one part of the region to the other. The farms in Lower Szigetköz (at Dunaszeg, Győrzámoly, Győr-Bácsa) produce under better conditions and at a higher level. In the majority of the region, the level of groundwater remained sufficient in spite of the diversion of the Danube. Deficiency in precipitation was significant (79-93 mm) in 1993. Although the decline in yields was primarily due to this deficiency, it was of a smaller degree (on the average 14.4%).

The endowments of the farms located in Central Szigetköz (at Ásványráró, Hédervár, Darnózseli, Lipót, Püski, Dunasziget, Halászi) vary significantly. There is usually more precipitation here. They had had a significant territory with high groundwater level, which declined into the gravel layer as a consequence of the diversion of the Danube. The relative precipitation surplus could not counterbalance the groundwater deficiency. Level of production here was around the average of Szigetköz. The decline in yields in 1993 was of medium degree (23.3% on the average), caused mainly by deficiency in the moisture content of the soil, due about equally to the smaller amount of precipitation and of groundwater. The endowments of the farms in Upper Szigetköz (at Rajka, Bezenye, Dunakiliti, Máriakálnok) are less favourable. Their level of production is below the average of Szigetköz. Decline in yields here was significant in 1993 (31%, out of which 20% was caused by water deficiency, for three fourths of which the smaller amount of precipitation, while for one fourth the decrease in the water table was responsible).

Forestry

After June 1993 partial water deficiency could already be visually seen in the case of the alluvial forests. Patches, mostly yellow, appeared on the leaves. Some branches shrivelled up. It was a general phenomenon from June on that the trees started to lose their leaves. They tried to counterbalance water deficiency by reducing their foliage (i.e. by a smaller transpiration surface).

By mid-June 3% of the alluvial forests had to be qualified as decayed. In July there was some more significant precipitation, the side-branches also became filled up for a short time, thus the rate of deterioration slowed down. From the second half of August and the beginning of September the loss of foliage and decay continued. At the end of 1993, 5% of the trees have to be qualified as decayed.

The 1993 decrease in the size of the spring-early summer timber, which has the greatest water demand, can be best characterized by the decline in the girth increment measured by the Research Institute of Forestry every week with 0.1 mm accuracy in several sample fields of the Szigetköz flood-plain. The data, compared to the averages of 1991-1992 (calculated from the beginning of vegetation to July 31st) are as follows:

- near the bank of the mainstream, e.g.

Dunasziget, plot no. 15/A 12-year-old I-214 poplar clone, 95 cm thick topsoil: 65% decrease in the girth increment;

Dunasziget, plot no. 15/B 13-year-old white (grey) poplar sprout, 180 cm thick topsoil: 70% decrease in the girth increment;

- in usual flood-plain situation, e.g.

Dunakiliti, plot no. 14/E 18-year-old I-214 poplar clone, 145 cm thick topsoil: 59% decrease in the girth increment.

The Dunakiliti data are important, because, though the communicating-vessel effect of the reservoir raised somewhat the groundwater levels in the area relative to those that would have been in the case of such low water level of the river as it was, I-214 poplar clone would also need the additional supply of medium and high water levels.

If the water table does not change to the better in 1994, an accelerating decay of the alluvial forests can be expected.

Fish biology - fishing

As a consequence of the diversion, water has completely flown out of 72% of the flood-plain side branches. In proportion to this, the bigger part of the fish fauna moved into the mainstream where some of the typical side-branch species (e.g. pike, carp, roach, tench) do not have even their most essential living conditions. Moreover, the situation is also critical because the conditions for the overwintering of the fishes should have been established just in the period of the diversion, when they would have needed intensive nutrition. In the mainstream there was not enough and not the needed sort of nutriment. The fish that remained isolated in the shallow remnants of water in the side-branch system either fell victim to predatory animals or got frozen in the ice during winter. 150-450 thousand kilogram of fish have disappeared or perished, 30-32% of which were economically valuable fish.

The living connection between the Old Danube and the system of side branches has ceased to exist; from the 53 spawning-grounds known by fishermen 20 ceased to function in 1993. 39 kilometres of the mainstream lost its sub-mountain character, its characteristic species migrated from here. As a result of the diversion, an upper part and a lower part of the flood-plain of Szigetköz became separated from each other. In the upper part, the water table became critically low after the diversion, and the earlier big uninterrupted sections became broken up into several small water surfaces. The conditions of migrating, getting nutriment and spawning became worse. In the flood-plain of Lower Szigetköz, which was less affected, strong silt deposition can be noticed which also decreases the level of the surface waters.

The number of developed fish decreased to 65-70% of that before the diversion, within this, that of flood-plain predatory fish to 30-35% of the former number. The amount of second-summer-old fry decreased by 20-30%. The dead channels on the protected side became dry during winter, their valuable fish fauna got destroyed. (In 1992, 61% less fish was caught in Szigetköz than five years before.)

According to the original plan, it would have taken about half a year to fill up the Dunakiliti reservoir, while the waters on the flood-plain and on the protected side would have received continuous additional supply. As a result of the diversion, the loss of water took place in a few days, thus adding to the negative effects of the power plant. Hence, it can be stated that the implementation of Variant C is even more disadvantageous than the original one.

Nature conservation

Due to the diversion of the Danube, Upper and Lower Szigetköz will be more characteristically different from each other than they have been. The dividing line will most probably be situated where the damming back effect of the Danube will be felt in some form (at about the Bagaméri branch system).

In Upper Szigetköz a radical decrease in the discharge and the water level of the Danube will effect the change and transformation of the there existing plant communities and will also affect the specific animal associations living in this area. Do the surface- and the groundwaters remain on the same level as now, it will terminate - in many cases slowly, but surely - the greatest value and the most characteristic trait of Szigetköz in a botanical and zoological sense, namely, very great variety on a small territory, the mosaic-like arrangement of biota. If the next two-three years are the same as this year, the original water-, uliginal and marsh-plants will be durably damaged. The size of populations will significantly decrease. In the longer run a reduction in biological diversity must be reckoned with. In 1993, partly due to the disadvantageous changes in the water table balance, also the protected flora showed signs of drought of a degree never experienced before.

The mortlake of Lipót and the Ásványráró-Öntéssziget Lake - both specially protected nature conservation areas - had become dry temporarily by the beginning of summer, owing to a complete loss of water. The artificial, i.e. pumped, supply of water into the mortlake of Lipót took place in the second part of summer.

It is difficult to form an unambiguous picture of the changes in the natural values of Lower Szigetköz which constitutes about a fourth of the whole territory of Szigetköz. It is highly probable that the value of this area from the point of view of nature conservation will rise. This territory is expected to be less dry, and all those changes which are expected to occur in Upper Szigetköz will either not take place here or only to a limited extent.

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