HYDROLOGICAL AND GEOGRAPHICAL COMPONENTS OF FLOODS OF THE TISZA RIVER

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If we assume that the history of Hungarian people is connected with our waters, that water must be the Tisza river. One fifth of the country's present area have to be relieved from the permanent flooding of the Tisza and its tributaries. That enormous anti-inundation work has neededthe efforts of generations. The country's publik opinionhas been paying great attantion not only to these works but to the buildings of barrages, and there has also been discussions about their real or supposed consequences.

Members of the most competent sciences, hydrology and geography, also are not exempt from these kind of ever renewing poemics. They represent similar opinions about facts and consequences of the intervention. There are not such similarities in the judgement of the degree of the problems which constitute the basis of valuations and the scale of quantity estimations. For this reason our opinion is that it is necessary to characterize the catchment area of the Tisza from hydrological and geographical aspects and to value the engineeric and other kind of human interventions. We have to pay special attention to the floods of the Tisza because the averting of its effects was a national aim.

Hydrological circumstances

In the practice of hydraulic engineers entioning the Tisza they usually mean the regulated lowland section of the river from Tiszaújlak to the mouth. It includes those parts of the river which belong to Hungaryand Jugoslavia. The headwater of he Tisza is consideredto be the part of the catchment area.

The lowland section has a very extreme individual hydrological character to such an extent that the river can be compared only with itself no matter if we examine it before or after the regulation. For that reason the scientific knowledge accumulated from the examination of other rivers or deduced empirically can not be extended or if can be, only with reservations to the Tisza. Hungarian hydraulic engineers have the special merit that they've found the possibilities for the ceasing of the inundations and changed the characteristics of the hydraulic regime.The main character of the lowland section is the extremely low value of the slope of the river bed and the level of the runoff water e. g. 4 cm/km from Szolnok to the mouth. The local deviations are smaller than 10%. Another important fact that the Tisza has many tributaries which have considerable output in comparison with the mainstream. The length of the runoff water of the tributaries are considerably differ from the mainstream. This explains that the lower half of the tisza about from Tiszabő to Szolnok is filled with the flood of the tributaries mostly by the Körös and the Maros. The floodwave of the mainstream will arrive later or it might not arrive at all. It can decay on the way or unite with other floodwaves because of the great floodwave of tributaries and the backweter of the Danube.

At the time of flood the hydrological independence of the headwater can be slayed by the small slope, the summarized influences of tributaries and the upward backweter from the lower sections. The floodwave of the Danuba, Maros or Körös can act like a built in barrage with everchanging height that can control the waterlevel of the mainstream by its own laws.

Influences of the early Tisza regulation

From hydraulic engineers' point of view the regulation of the Tisza between 1846 and 1908 had two impoportant goals:

- to embank the river for averting the spreading of flood
- to shorten the flow by cuttings and to obtain the proper bed shape and the better outflow.

Because of the embanking the level of the flood increased with about 3 ms. That was the greatest human intervention conserning the flood flowing of the Tisza. Other suppossed human intervention, first of all, the changing of the line of cultivation influencedon the floods of the Tisza but these increasings weren't higher than 10–20 cms even by the most extreme countings. So if we mention the increasing flood levels of the Tisza, we have to observe that these values are only up to some cms but in most cases only to some cms. If we compare these values to the great increasing of flood level made by the embanking, we'll find them neglectible. There is not much sense in couting those cms and dms which originsare not clear especially, if we remember that the engeeniers of the previous century had a much bigger problem, namely the 3 ms increasing of water level. Could that 3 ms increasing have been avoided? Not at all. We had to pay that price for the antiinundation work. The water which could inundate certain areas that time had to appear somewhere else and had to rlow away. It remained between the embankments above the old mass of water. That way it could discharge faster than before. The run off conditions of the Tisza make it possible that after each 3 ms increasing of the water level the amount of the transported water can grow twice as much as it was before. So after the regulation the river can safely transport twice as much water as it could in its natural state. Moreover, the protecting ability of the embankment could handle the safe transportation of the water even if it was three times more.

The greater the area where the anti-indundation work was done the greater amount of water has to move between the embankments and the higher level of the flood we have to count on. That is well proved by the example of the summer dikes in Szolnok county. In the last century the anti-inundation work has not been done on some smaller diked march bat later he protection with embankment deemed necessary at least in summers when floods are smaller and lower embankment can protect the fields. As a larger amount of water was separated, at once an increasing of water level was observed in the area of the summer dikes. In some parts it even influenced the highest water level. If we confuse the influenses of the known interventions with the supposed ones, it carries the danger of drawing the wrong conclusion.

Pál Vásárhelyi the planner of the Tisza regulations suggested small interwals within the embankment and many cuttings. The suggested 102 cuttings weredone with slight differences. The system of the narrow intervals and cuttings are supplementary to each other. If the intervals were bigger, the increase of flood level would hardly decrease and the runoff would not become better. Winding rivers like the Tisza can not embank closer to the bed without cuttings. That is why most of the old river beds could get out of the embankment.

We can find such wrong ideas evenintechnical circles that the descending of the flood waves of the shortened rivers became faster because of the increasing of the slope. The moving of flood waves could have made faster by the narrowing of the waterspreading area but this influence is limited by the backweter of the Danube and the Maros. Basic improvement could have been reached only by descending the water level of the river Körös, Maros or the Danube. While the backweter of these rivers exist the floodwave can not leave the Tisza in spite of all cuttings and inceasing of slope the river bed. If the state of the backweter ends and the water level is decreasing the runoff will be faster and the floodwave wil be ending too. There is an importance of the water transporting ability ofthe bed. We can see that between the embankments the discharging of the river is better than when the spreading water would have to find its way back across the fields. Although the regulation has overcome some difficulties of the permanence of the flow bat there were not fundamental changes because in most cases the Tisza looses its hydrological independence and other rivers can influence on it

For better understanding we have to note that the runoff velosity of the river and the flow velocity of the floodwave peaks are two totally different ideas. According to the *Chézy's* formula the runoff velosity is in connection with the decline of the water level (with its square root) and the values of the bed shape and roughness. The run off does not take away the peak state. It is an effect of the mowing water which is independent from the forward moving of the water particles (We can observe such a wave-like effect on the wheat fields, where the moving made by the wind is independent from the state of movement of the basic medium.) The local correction of the run off velosity could suceed by cuttings. This is good result from the aspect of the river regulation and bed shaping. The fastening of the floodwave velosity could not succeed because the basic conditions of the water level's bakweter developing couldn't be changed because of the influences of the Danube and the tributaries.

The next problem of our investigation is the degree of influence of the barrages in Tiszalök, built in1954, Kisköre-set to work in 1973 and Törökbecse which has been working since 1976. At the time of floods damming up is impossible in these barrages.

Sotthey haveno increasing influence on floods. Naturally in the case of medium orlow water they change the original hydraulic regime.

At highlands the water storage has two different influences. While the flood is small the scale of the flood is reduced by the storaged water. But when the flood is greater it will fill up the storage volume. So the influence of the storage comes to an end. If the basins are handled wrongly or any catastrophy happens the volume of the storaged water will increase the influesnce of the natural flood. This way increasing of the flood level and the flood Ascharge is possible. In the water regime of the Tisza this phenomenon has not happened so far because most of the storages which can have any influence on floods are still future plans.

In Czecho-Slovakia a developed storage system has been working since the 60-ies at the catchment area of the Bodrog. This storage system has smaller water holding capacity than being able to receive all the water of the floods of the Bodrog. In the case of greater flood waves the urgent letting down of the water from the partially or totally filled storage is usually necessary or it can not receive new amounts of water It might happen that for a longer period – even for days – they keep letting a much water into the bed of the Bodrog as is necessary for reaching its avarage water level. This long time water loading undoubtadly influences the flood flow order of the Tisza: it can extend the duration peak of the middle part of the river. On the other hand it limits the height of the peak level because of moderating the very high peak loads by the considerable extensing of the high water level.

It is undoubtadly true that the flood influencing effect requires rather many and great volumes of the directly flood moderations or additional storages forthe effective influence on the whole river.

The early river regulation has changed the stream deposit conditions by the settlement of the river bed. It is obvious that the widespreading water spreaded its deposit to the steepening of the runoff made better possibilities for the transition of the stream deposit than sibilities for the transition of the stream deposit than it was in the original state of the river with those windings and a small slope. It isalso obvious that the deposit increased at some sections of the flood plain and in other places just the opposite phenomenon has appeared, namely drifting. These phenomenons are considered to be local characteristics by hydraulic engineers. They dry to influence the runoff and the settlement of the deposit continuously by the instruments of the river regulation: building of dam dikes, training walls and dykes by the requirements. The river can be influenced but we most respect its own characteristics. Sometimes the river agrees, sometimes it does not then other instruments must be introduced. We have not yet experienced such a fundamental change that could be dangerous and irreversible to the bed or the flood plain and would influence the river as a whole, since the completion of the great regulation work.

The main goal, releasing one fifth of the country from the inundation has been reached by the embaking of the river and the shortening of bends by cutttings. For this we had to accept the increasing of the flood level with about 3 ms and all the problems of the organized flood prevention works.

We had to do the preservation works of the river regulation. The technical intervention could always give the proper stability of the runoff and the deposit conditions of the river. If any leak occured in the effectiveness it was only a local problem and could be solved by technical instruments. It would't be right to extend some local problems to the whole river.

Altenating of the flood free and floody periods in the hydrological history of the Tisza

We can count on the manifestation of the effects of the embankment since 1876. According to the experiences of the last 108 years we can say that the distribution of the annual high water levels are statisticaly homogenous between Vásárosnamény and the mouth of the river. It follows the Gaussian distribution with very good approximation. We can say that the floods of the Tisza are controlled by incident factors. Within the wide possibilities of the incident controlled hydraulic regime the river has been the same since the beginning of the embanking to nowdays. Other influences (embanking with summer dikes, human interventions on the catchment area) might have played a great part in it but the scale of these is considerably smaller than the scale of fluctuation wich were made by the incident units of the hydraulic reegime.

We must not think that the incident units of the hydraulic regime has the characteristics that in the case of the occurence of some extreme event the nature isin a „hurry" to get back the balance *at once*. It would be just the opposite extremity. Experience shows that the floody years are forming a group and so are the flood free years. So there can be periods longer than a decade or even decades, when rather manyand high floods are occuring and there can also be longer periods when the occurence of high water levels are absolutely missing.

Unfortunately the observed 108 years period wasn't long enough for the statistical valuation to predict the coming of the floody or flood free periods with great accuracy. It is obvious that there had been many floody years from the beginning (probably since 1855) to 1895 e. g. 1876, 1877, 1879, 1881, 1888, 1889 or 1895. From these years there were extreme floods in 1888 and 1895. Between 1896 and 1912 the water level of the Tisza exceeded 700 cms only once and only for a short time at Szeged. In the above mentioned years it often exceeded the 800 cms level, moreover it was near 900 cms. There were floody years between 1912 and 1942 too: 1912, 1913, 1915, 1919, 1924, 1932, 1933, 1940, 1941 and 1942. From these years there were very high floods were missing again between 1942 and 1961. In this period the 700 cms water level was slightly exceeded three times for a short time at Szeged. We have been in a floody period since 1962. It is very unlikely that this period came to an end in 1982. The most significant floods of that period were in 1962, 1964, 1965, 1966, 1967, 1970, 1974, 1975, 1977, 1979, 1980 and 1981. The floods of 1970, 1979 and 1981 were unusually big.

From these three floody and two flood free group of years we can only recognize their existence, but we must not draw any conclusions. Although the opinions of competents and incompetents can be influenced by the fact whether they were formed in floody or in flood free periods. Most people tend to generalize the characteristics of a longer period to the future. In floody periods they note only the increasing levels of the frequent floods. Flood free years support those opinions that some unknown reason or intervention made the rivr stop its floodings.

Today's danger is the overstating of the floody character. Since 1983 those opinions has been spreading more and more which were counting on the remaining of the frequent floods and were looking for the reason of a supposed change in nature. They think that the definitely increasing highest water levels are showing some tendency. It might happen that the temporary missing of floods will support some theories about the drought.

The fact that we consider the occurance of the „record breaking" by the output of the flow and the water level incidental, does not mean that we think the development of the embankment-building is perfect. We mean only that for the determination of the embankment height we can rely on the results of the statistical evaluation of the dataseries. According to the aim of the prevention we can choose from the building heights relying on the possible highest flood level occuring once in a hundred, two hundred, five hundred or even thousand vears. It does not mean that a higher flood level is impossible . But nature may cause these accidental increasings and we do not have to look for unknown human interventions from any sources.

Hydrological independence of the Tisza

We can consider the flow regime and the floodwave of a river hydrologically independent if the characteristics observed at lower gauges can be deduced from the previous characteristics observed at the upper gauges. The only reason ofthe phenomenons observed at the lower gauges are what had happened at the upper gauges. If one or another outlet or tributary can make any influence, the mainstream will loose its hydrological independence and comes under the donimation of another river at the time of the influence.

The Tisza has a hydrologically independent flow regime if the tributaries are subordinated and the water level of the Danube is not only low is decreasing permanently. It occurs rarely and is not authorative because in the case of very high downward floodwave there would be enough space for it under the mouth of the tributaries because of their delay.

The Tisza and its tributaries can loose their hydrological independence very soon adn easyly because the slope of the water level is so small at the lowland section that the influences of the damming up and the lowering is caused by natural reasons, not by the barrages which can manifest easily. Thinking it over, we can realize that in the bed of the flooded Tisza there can be 15 md or even higher water. Suppose the above mentioned 4 cm/km decreasing of water level (in the case of natural damming up the value is somewhat less). There is 4 ms difference in height in every 100 kms. So we can go away almost 400 kms and the level line will remain in the bed.If we draw a level line from the level of the lower river section, the line will remain in the bed of the river and will slightly touch its bottom. It can happen in every case of the floods when the water of the Maros and the Körös arrive to the Tisza before the floodwave of the mainstream could arrive. The water of these two rivers can do the damming up at the upper section of the Tisza. If the floodwaveof the tributaries ended (in common words „ran out") The direction of the peak flood level should be upward. The characteristics of the mainstream flood will develop under the domination of the tributaries.

In most cases the strong floodwave of the Maros is dominant on the great floods of the Tisza. Usually the ending of the floodwave of the Maros causes the peak at the lower section of the Tisza under Szolnok or Kisköre. The water of Körös usually flows away when the Maros is still flooding and damming up the waterabove the mouth of the Körös. The Körös looses its hydrological independence because of the Tisza, and the Tisza because of the Maros this way. It happens that the Danube is dominant aabove the floodwave of the Maros and doesn't let the peak of the Tisza happening until its own peak would not happen. It is also characteristic that the floodwave of the Tisza ends when the protection ability of the summer dikes are over and the areas situated behind them are overflown.

If the peak of the Tisza depends on the floodwave of the Maros or the increasing or decreasing water level of the Danube at the mouth or more likely the protecting abilities of the summer dikes at Alpár what could be the value of those conclusions which suggest that some kind of activity on the catchment area occurs from the changings of the peak level, which are dependent on many factors and in most cases are not independent of hydrological point of view? If any nondesirable activity (e. g. changing of soil drifting, influences of urbanisation etc.) occurs their hydrological or geographical consequences ought to be sought near the reason. Then further consequences could be analysed as the determinated consequences of a determinated and measurable reason. During the analyses of the characteristic water levels it would be obvious to distinguish cases, when some important event happened in the hydrologically independent state of the river, and other cases when the domination of other rivers were influential

We must not make certainty from the coming up hypothetical explanations of the observed and immediately unexplainable phenomenons of the Tisza. The professional and nonprofessional public opinion has numerous prepared explantations and they are spreading them with pleasure. They usually conclude from these explanaions too, but msot of the time no exact, professional evidences are given. It has been a popular theory for about a 100 years now that human intervention has an influence on the catchment area and this is considered to be the cause of those kinds of flood level changings ofthe Tisza of which we do not even know whether they existed on the independent flow, or not, or if they are tendentious, or even if the scale of the supposed reasons could give grounds for similar changes.