

Ph.D. Thesis Abstract
Doctoral School of Earth Sciences

The river regulation effect on the regime of Hármas-Körös

Ph.D. Thesis

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1. Introduction

Choosing the theme of my dissertation has been motivated by several subjective reasons. First of all I had spent the first 18 years of my life in Békésszentandrás, near the River Hármas-Körös. The second motivation was that during my secondary school I started to deal with the evolution and the regulation of Körös Rivers and I was also interested in the river exploitation in the past and present. For the third: my supervisor Professor Emeritus Dr. Ferenc Schweitzer has been highly patronizing my fluvial researches of the River Hármas-Körös. For the fourth and last my father is greatly acknowledged, who has used to tell me several stories about the big flood in 1970.

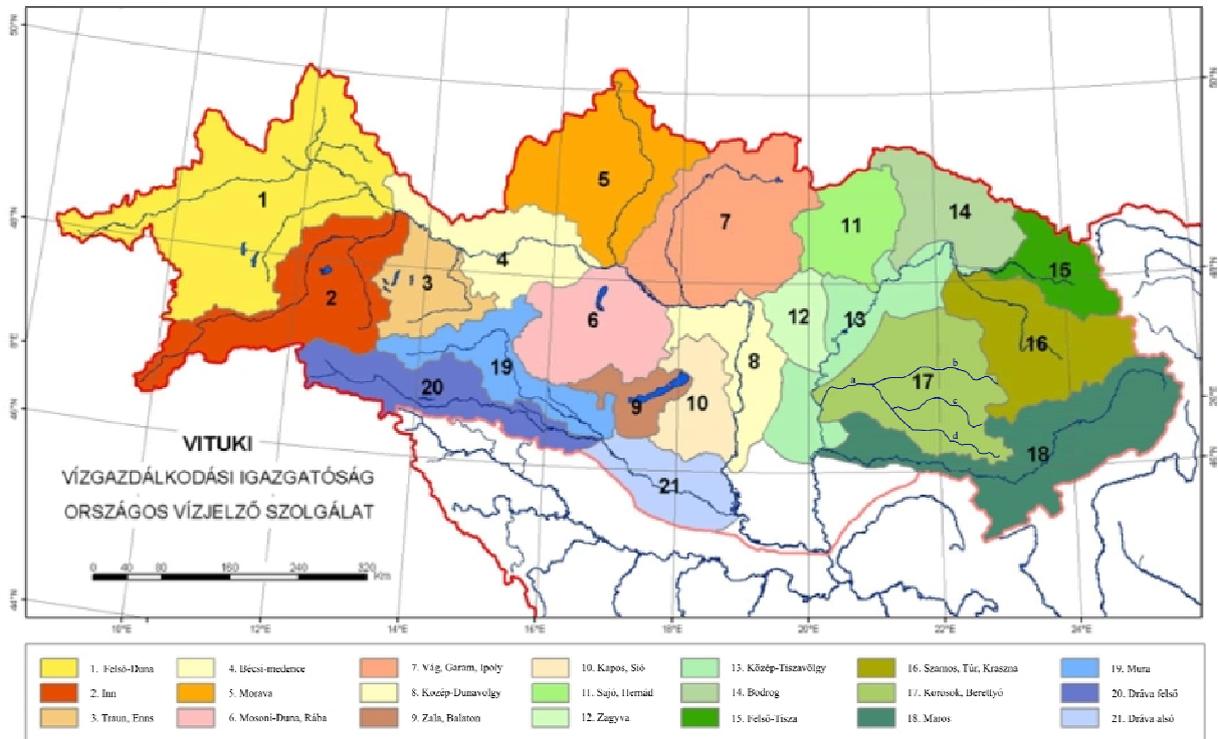
Prior to the river regulations and the drainage of the marshland the decisive part of the Hungarian Plain was a real waterworld. With the river regulations, 459 kilometres from the Körös Rivers have been cut away. The width of the active floodplain turned to be very narrow: with a fence of parallel barrages 150 thousand hectares active floodplain was trimmed to 11,500 hectares. The flood risk (spring, summer) hasn't been stopped so far, nowadays it is still threatening the settlements. During high water or flood, the rivers carry multiple amount of water comparing to their medium water amount (RÓNAI, A. 1985).

The total catchment area of the River Körös and Berettyó is 27,537 km² that means it is on the second place in range from the tributaries of the Tisza River and 11,950 km² from that terrain is situated in the hill and mountain region. The following rivers are belonged to the Körös water-system: Fekete-, Fehér-, Kettős-, Sebes-, Hármas-Körös, Berettyó and Hortobágy–Berettyó (*Fig. 1.*).

„Every watercourse is an individuality, which we would like to characterize with numerous natural science factors. On the other hand we have to determine that the long-term monitoring of the watercourse is indispensable to our works” – had written by PICHLER J. in 1954 on the pages of Bulletin of Water Resources. Following this idea during my explorations I analysed the changes of the low, the medium and the high water level with mathematical-statistical methods on two water stations by Hármas-Körös – Kunszentmárton, Gyoma looking through over a 100 years time interval (1907–2006). I tested in details the different attitudes of the big floods in 1919, 1970 and 2006. I was very curious if there is a possibility to demonstrate some cumulative or regressive tendencies of the floods of Hármas-Körös. I was also interested in of the possible effects on Tisza floods caused by the Körös Rivers floods. I reviewed the process of the river regulation, I also analysed its positive and negative

impacts and consequences. I studied the development of the Hungarian law of the Water Resources from the beginning to the turn of the 19–20th century.

Fig. 1. Catchment areas of the Carpathian Basin.



From VITUKI, edited by BABÁK K. 2010.

2. Aims of study

With this research I would like to explore the changes of the riverbed and the water level in Körös–Berettyó water-region. This work meant to add particular knowledge of the Körös–Tisza relation. The indirect aim is to expand the database about the project region in case of analyzing the low, the medium and the high water level. I would like to find answers for the following questions:

- What is the reason of expansion the number of studies about the active floodplain and riverbed from Tisza and its tributaries in the last two decades?
- How the river regulation could have affected the life of Körös-region?
- Wherein could help to set up the legal background in realizing the river regulations?
- Which have been the most often low and high water level periods in the last 100 years at the water station Gyoma and Kunszentmárton?

Thesis 1. The low water level of Hármas-Körös is not the lowest during summer time, the high water level occurs in spring and summer.

- Is it possible to show any tendencies of the high water level of Hármas-Körös?

Thesis 2. The high water level of Hármas-Körös shows cumulative tendency.

- Was there any change in the interval of the high water during the three extraordinary floods?

Thesis 3. The interval of extraordinary floods on Hármas-Körös is growing, but the time between two extra floods is decreasing more and more.

- How strong is or is there any damming impact of Tisza River at the water station in Gyoma and Kunszentmárton?

Thesis 4. The proximity of Körös–Tisza mouth affects in a large scale on the water station in Kunszentmárton, but it has lower impact on the water station in Gyoma because of the bigger distance from the mouth.

- Is it possible to detect similar amount of flood deposit which are in the bank of Mid- and Lower Tisza by the sampling at sight?

Thesis 5. The amount of flood deposit of Hármas-Körös is consistent with Mid- and Lower Tisza.

3. Materials and methods

3.1. Field methods

- Geomorphologic mapping from 1:10 000 scale maps
- Application, description and drawings of cross sections
- Manual drilling
- Sampling: from all the levels, layers and materials

3.2. Physical methods

3.2.1. Granulometric measurements

The alluvium, which has built up the north side of the Körös–Berettyó region, was transported by the Tisza, Hortobágy and Berettyó Rivers, the south side was carried by Körös Rivers (STEFANOVITS P. – FILEP GY. – FÜLEKY GY. 1999). Close to the rivers silt, far away

slowly consolidated clay was deposited. Based on particle size analyses, we could get information about the common size and assortment of the deposited sediment, and we also got data about the energy of water and from environment.

We have determined the particle content of the sediment samples using the pipette method in the Laboratory for Sediment and Soil Analysis of Geographical Research Institute of Hungarian Academy of Sciences. The matter of the pipette method is that we made limited volume sampling from limited depth after deposited time, than we could measure the distilled dry volume of the particle fraction. So we could represent the result of 100 grams sediment. Our research results were represented on the particle size distribution graphs.

We analysed the sediment samples from Szelevény and Békésszentandrás using laser diffraction Fritsch Analysette A22–32 in the Laboratory of Physical Geography of University of Pécs. The laser diffraction analyser can measure within 300–0,3 μm range without interpolation made 62 channel particle size. The results are presented on particle size distribution graphs and Passega LM and AM graphs.

3.2.2. Humus content determination with colorimetry method

The humus content of Hungarian soils are usually 0,5–6%. The higher area of Körös–Berettyó region is covered by sand and meadow chernozem and chernozem with calcareous coated lime soils, the deepest area is covered by meadow and saline soils (STEFANOVITS P. – FILEP GY. – FÜLEKY GY. 1999). The humus content determination is applied to define organic composition of our sediment samples. This data refers to the first step of the soil formation.

With laboratory analysis we could calculate not only the real humus material, but even the total organic contents too. The method is based on the attitude of the organic materials that they are easily oxidisable.

3.2.3. Lime content determination with Scheibler calcymetry

The soil lime content is usually characterized by the level of carbonic-acidic lime content, because of the lime takes advantageous effects on the stability of soil elements and soil texture too. In case of our sediment samples we were looking for the answer if the first step of the soil formation has started already, because this fact would refer to higher lime content.

3.3. Mathematical-statistical methods

We took Oracle Crystal Ball 11.1.1.3.000 software for modelling our 100 years database with mathematical-statistical methods. This program is able to consider the probable distribution of every hydrogeological parameter. We used Anderson–Darling, Kolmogorov–Smirnov, Chi-Square tests for our analysis, because these software automatically calculate several different scenario of the „what is it, if” question.

Applying the T-test by Student we checked the uniformity and the extremity of high water level regime on Hármas-Körös River.

With the Rho-test by Spearman we looked for growing tendencies in big floods (above 200 centimeters of the first level of flood prevention preparedness).

4. Research background

One of my goals is to show the main trends of floodplain research and analysing methods of the Hungarian part of the Tisza River water system. I review these methods separated in thematic groups (riverbed instability, estimated or directly measurement of active floodplain, morphologic researches).

During of my work I reviewed the representative Hungarian journals – *Hungarian Geographical Bulletin* 1952–2009, *Geographical Review* 1873–2009, *Bulletin of Water Resources* 1890–2004, *Hydrological Bulletin* 1920–2009, *Hydrological Prospectus* 1961–2009, *Water Management* 1960–1978 and *Hungarian Water Management* 1978–1991, *Image of Water* 1992–2001 – referring with longer or shorter essays to my research themes. I collected, systematized and evaluated the studies, monographs and book chapters about the regulation of Körös–Berettyó region.

In the first decade of the 21st century every researcher agrees that continuous riverbed cut in and active floodplain sedimentation have been happening since the beginning of the river regulations during the last one and half century. The previous one has two directions: first the horizontal and than the vertical movement (sinking, upgrading) of the riverbed.

On the whole we can say that in the last two decades the number of studies about the active floodplain and riverbed of the Tisza River and its tributaries has expanded. The question of growing or sinking of water level and runoff with big floods (floods of 1998–2001 and 2006) was set into the focus of the professional interest.

Nowadays these dissections point to a timely problem, because 2–2,5 million people live currently on the Hungarian floodplains. The floods of the last 160 year demonstrate that the Vásárhelyi's dreamed system of Tisza doesn't work properly. The flood level is growing despite of the sinking runoff. In the 20th century happened several times (1919, 1925, 1940, 1948, 1970, 1974, 1998, 1999, 2000) that the flood level achieved or passed the height of the dikes (SCHWEITZER F. 2003), therefore since 1850 the height of the dikes was stilted seven times.

This fact is raised the following question: we have to choose a new strategy, or other premeditation we have to prepare for a disaster. This is a national security problem.

5. Conclusions

The thoughts of IVÁNYI B. (1948) are valid today too, we have no doubt in the corrective of Tisza regulation. The flood immunization of the Hungarian Plain, the regulation of Tisza realized their aim on an alone amenable way. Its posterity is not a question, but the applicant errors during 160 years can not be eliminated, but must be compensated.

I show the aims of my research in the mirror of my results in the following.

- What is the reason of expansion the number of studies about the active floodplain and riverbed from Tisza and its tributaries in the last two decades?

In the last two decades the number of researches about the active floodplain and riverbed from our rivers has expanded, so that we can see the exponential growing number of studies in the representative journals of geography of sciences and hydrology (Geographical Review, Hungarian Geographical Bulletin, Hydrological Bulletin, and Bulletin of Water Resources). The growing or sinking of water level and runoff, the questions of the frequency and permanency of floods usually put the theme in the main focus of the professional interest for example in case of big floods (floods of 1980–81, 1998–2001 and 2006). Today on the Hungarian floodplains at the neighbourhood of the rivers approximately 2–2,5 million people live. On these fields many different type of economical structures (residences, public roads and railways) have been built since the beginning of the river regulations.

The created protection system at the Tisza River dreamed by Vásárhelyi doesn't operate perfectly. The flood level is growing permanently, so it could happen several times in the 20th century that the flood level achieved or passed the height of the dikes (SCHWEITZER F.

2001, 2003). The height of dikes can not be raised endlessly, because of it has got physical and also financial limits.

- How the river regulation could have affected the life of Körös-region?

The river regulation has changed radically the health-condition of the Hungarian Plain's inhabitants. The waterlogged areas were the centre of serious diseases like swamp fever or different epidemics when these terrains were covered by water permanently for a half year. During the flood immunization 15.500 km² sized area has been exempted of water, with that huge areas turned to be able to use by the agriculture. These impacts strengthened those tendencies, which helped to increase the number of inhabitants spectacularly (in some settlements the number of inhabitants grown to its duplex or triplex within a 30-40 year-long period), it caused more and more cultivated acreage, that it changed the cultivation method at the end (conquest of the garden area's rate).

- Wherein could helped to set up the legal background in realizing the river regulations?

The XXXIXth statue of the year 1871 (from the river regulation association) along every river the owner has the right to form a river regulation association with the interested parties. The regulations have to be fulfilled without causing any damage; they have to be carried out with the approval of the competent authority. Design plans and execution works of the river regulation and water exemption processes have to be made on the own cost by the interested proprietary or associations.

The XLth statue of the year 1871 (from the dike police) the dikes reservation and protection first of all the task of the association, secondly of the local government, thirdly of the state. Every defect has to be regulated and repaired on the dikes and the protection structure, and after each flood maintaining of the dikes is the own charge of every association.

The XIVth statue of the year 1884 (from Tisza River) put as a duty (on their own-cost) of the association the flood immunizations and inland water regulation works, while the riverbed regularization was put as state-interested duty. The base of the floodplain development was the highest measured flood level.

The XXIIIth statue of the year 1885 (from the water law) says cleaning the riverbed and coastal proprietary, the attention and grooming of the riverbed and channels of the floodplains and of the coasts are the role of the owners of the coasts, the costs rate is defined

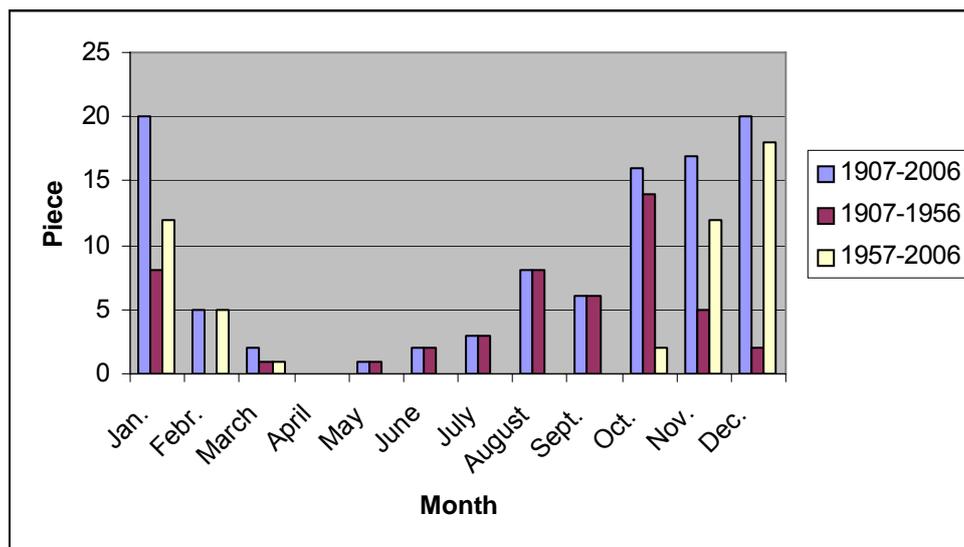
by the benefit. The flood immunization associations have to set up water stations and have to hire sufficient number of continual guards.

- Which have been the most often low and high water level periods in the last 100 years on the water station Gyoma and Kunszentmárton?

Thesis 1. The low water level of Hármas-Körös is not the lowest during summer time, the high water level occurs in spring and summer.

During the examined 100 year-long period (1907–2006), the 57% of the lowest water levels at Gyoma had happened in the winter months (November, December, January) but prominent from the autumn time is the October too (*Fig. 2.*). The lowest water level at Gyoma was –116 cm on 3rd of August 1930 which has been repeated on 23rd of October 1935. During the 100 years the annual lowest water level was measured only 12 times above zero on the station (1965, 1966, 1977, 1981, 1988, 1992, 1996, 1998, 1999, 2002, 2004, 2005).

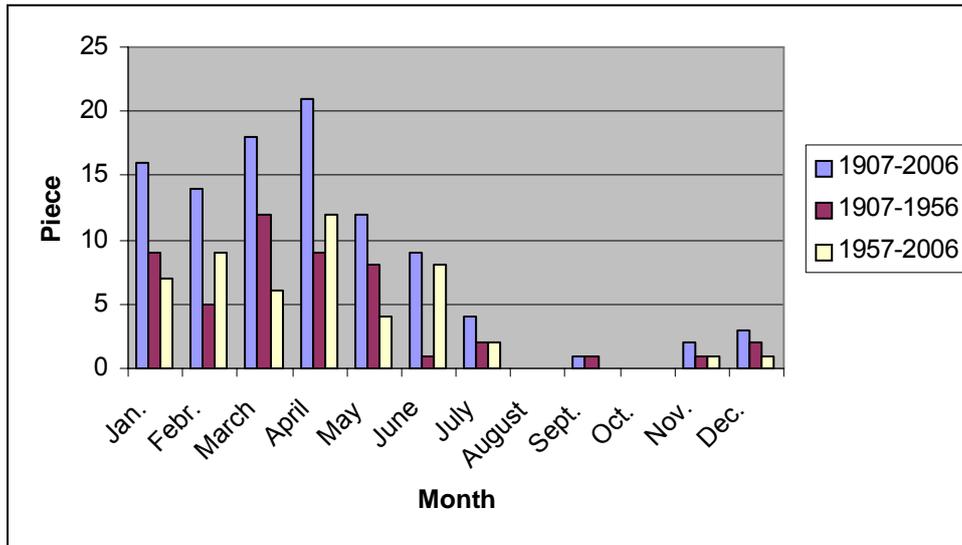
Fig. 2. Low water level in monthly distribution in Gyoma, between 1907–2006.



From data of Hydrographical Yearbook, edited by BABÁK K. 2009.

The high water level happened the most often in the first five months of the year (*Fig. 3.*). The smallest high water level was at 365 cm on 9th of July, 1990, the biggest high water level was at 918 cm on 14th of June, 1970. During the 100 years long period, the annual highest water level was only 5 times above 850 cm.

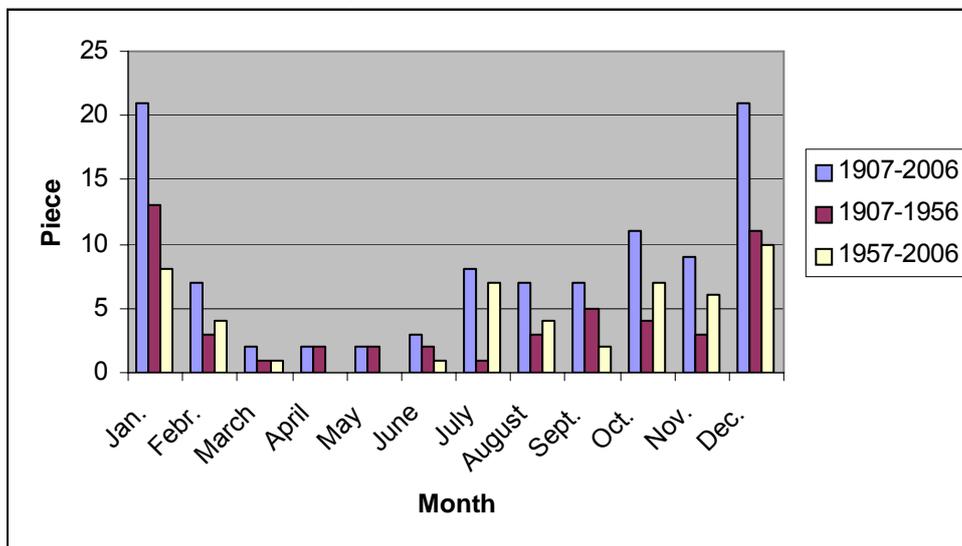
Fig. 3. High water level in monthly distribution in Gyoma, between 1907–2006.



From data of Hydrographical Yearbook, edited by BABÁK K. 2009.

The low water level in Kunszentmárton has happened the 69% of the times in winter time, but it is also prominent in September and October from the autumn period (*Fig. 4.*). Lowest water level of Kunszentmárton was at -240 cm on 24th of August, 1946. During the 100 years long period, the low water level was measured only 4 times above zero (1913, 1915, 1943, 1948).

Fig. 4. Low water level in monthly distribution in Kunszentmárton, between 1907–2006.

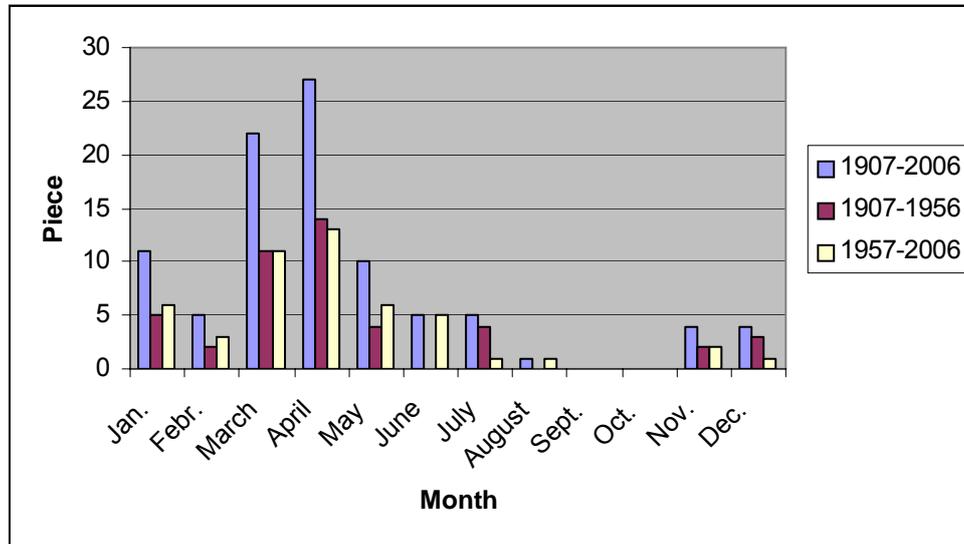


From data of Hydrographical Yearbook, edited by BABÁK K. 2009.

The high water levels happened the most often in January, March, April and May (*Fig. 5.*). The smallest high water level was at 280 cm on 5th of March in 1990, the biggest high water level was at 1041 cm on 21th of April in 2006. During the 100 years long period the

high water level was 10 times (1919, 1924, 1932, 1940, 1941, 1970, 1979, 1999, 2000 and 2006) above 850 cm.

Fig. 5. High water level in monthly distribution in Kunszentmárton, between 1907–2006.



From data of Hydrographical Yearbook, edited by BABÁK K. 2009.

- Is it possible to show any tendencies about the high water level of Hármas-Körös?

Thesis 2. The high water level of Hármas-Körös shows cumulative tendency.

The matter of the T-test of Student is that we made from our 100 years high water level (NV) database two 50 years high water level database, than we calculated the mean (KNV = medium high water level) and the standard deviation of these two database too. If the KNV variance of two databases we have compared with the whole primal standard deviation, we could establish that the KNV variance had a normal distribution with 95% or not. This has the following condition:

$$t = \frac{|KNV_1 - KNV_2|}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

This value was not allowed to exceed the threshold (1.96) of the condition. The n_1 and the n_2 are the number of the elements which were taking part in our research (in our case both of them are 50), σ was the empirical standard deviation of the high water level distribution.

Our calculations (*Tab. 1.*) have proved that in 1907–1956 and 1957–2006 half centuries the comparison data from the two water stations of Hármas-Körös River did not denied our assumption, that the variance of the two 50 years period are not significant. This showed that they came from the same statistical numbers and same regime. The KNV

variance of Gyoma is just 11 centimetres, but in Kunszentmárton it is 56 centimetres. According to the T-test the second one is also not significant.

Table 1. The medium high water level and standard deviation of Hármas-Körös River during 1907–1956 and 1957–2006.

Water station	KNV (cm)		σ (cm)		t
	1907–1956	1957–2006	1907–1956	1957–2006	
Gyoma	627	638	129	151	0,39
Kunszentmárton	628	684	137	152	1,94

From data of Hydrographical Yearbook, edited by BABÁK K. 2010.

Reviewing the database of the whole 100 years period, the KNV values on the two water stations were changing on a smaller scale than the variation of KNV in comparison of the two half centuries on the same water station (*Tab. 2.*). The values of the empirical standard deviation are also close to each other (the difference is only 5 centimetres in the two water stations). 95.4% of the incidence cases were straddled by the $\pm 2\sigma$ value high water level, but the biggest high water level (LNV) was not reached on either of the researched water stations. The difference was 5 centimetres at Gyoma, and it was 95 centimetres at Kunszentmárton. We enlarged the KNV value by 2.33σ , so then we could have estimated the common once-in-every-100-years high water level value, at Gyoma it passed the so far biggest LNV by 41 centimetres, at Kunszentmárton it was below the LNV by 47 centimetres. We calculated with the $KNV+3\sigma$ value then we got the value of high water level which can happen 1.3 times in every thousand year: this is higher than the present LNV with 135 centimetres at Gyoma, but it is only 50 centimetres higher at Kunszentmárton.

Table 2. The medium high water level, standard deviation and extremes of Hármas-Körös River during 1907–2006.

Water station	KNV (cm)	σ (cm)	KNV– 2σ	KNV+ 2σ	KNV+ $2,33\sigma$	KNV+ 3σ	LNV
			95,4%-os számköz		1% NV	1,3‰ NV	
Gyoma	633	140	353	913	959	1053	918
Kunszentmárton	656	145	366	946	994	1091	1041

From data of Hydrographical Yearbook, edited by BABÁK K. 2010.

The analysis of the behaviour of the big floods (200 centimetres higher than the first level of flood prevention preparedness) we created by applying the Rho-test of Spearman, this method gives a responsible result to indicate growing tendencies. The first step of the method was that we ranked the elements of database in growing order. If the original timeline has resulted in growing tendencies, so then the higher water level has a higher rank, then we used the following statistics:

(1) $d = (r_1-1)^2 + (r_2-2)^2 + \dots + (r_n-n)^2$. The more the growing tendency we can indicate in the researched series, the less the value of d statistic. If our timeline has no tendency, then big n value gives d statistic asymptotical normal distribution

(2) $E[d] = \frac{n^3 - n}{6}$ expected value and

(3) $D[d] = \frac{n(n+1)\sqrt{n-1}}{6}$ standard deviation (LEHMAN, L. 1975, BARABÁS et al. 2004).

According to our calculation $d = 1699.5$ at Gyoma. Because $n = 23$, we received from (2) and (3) formulas, that

(4) $E[d] = 2024$ és $D[d] = 431,5$.

If the hypothesis, that there is no tendency in the data line, is true then it has 95% of chance that d statistic falls into the following interval:

(5) $(E-2D; E+2D) = (1161; 2887)$.

We could have determined that the topical value of d statistic was in the given range, it resulted that there was no demonstrable mathematical tendency in the data line at Gyoma.

By right of our calculation $d = 2691$ at Kunszentmárton. Because $n = 26$, we received from (2) and (3) formulas, that

(4) $E[d] = 2925$ és $D[d] = 585$.

If the hypothesis, that there is no tendency in the data line, is true then it has 95% of chance that d statistic falls into the following interval:

(5) $(E-2D; E+2D) = (1755; 4095)$.

We could have determined that the topical value of d statistic was in the given range, it resulted that there was no demonstrable mathematical tendency in the data line at Kunszentmárton same as Gyoma.

- Was there any change in the interval of the high water during the three extraordinary floods?

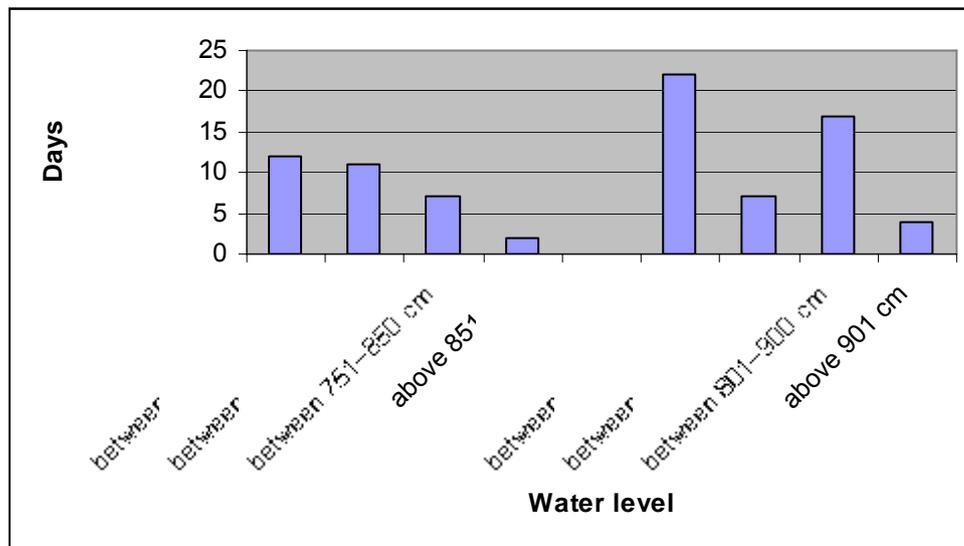
Thesis 3. The interval of extraordinary floods on Hármas-Körös is growing, but the time between two extra floods is decreasing more and more.

- How strong is or does it have any damming impact of Tisza River on the water station in Gyoma and Kunszentmárton?

Thesis 4. The proximity of Körös–Tisza mouth affects in a large scale on the water station in Kunszentmárton, but it has lower impact on the water station in Gyoma because of the bigger distance from the mouth.

The flood of Hármas-Körös River in 1919 by Gyoma took 32 days (Fig. 6.). The flood culminated on 4th of May at 873 centimetres, it exceeded the LNV of 1915 by 65 centimetres. (The flood of Tisza River was taking 50 days in 1919 by Csongrád. It culminated on 13th of May at 929cm.)

Fig. 6. The distribution of flood-days of Hármas-Körös River in 1919 by Gyoma and Tisza River by Csongrád.

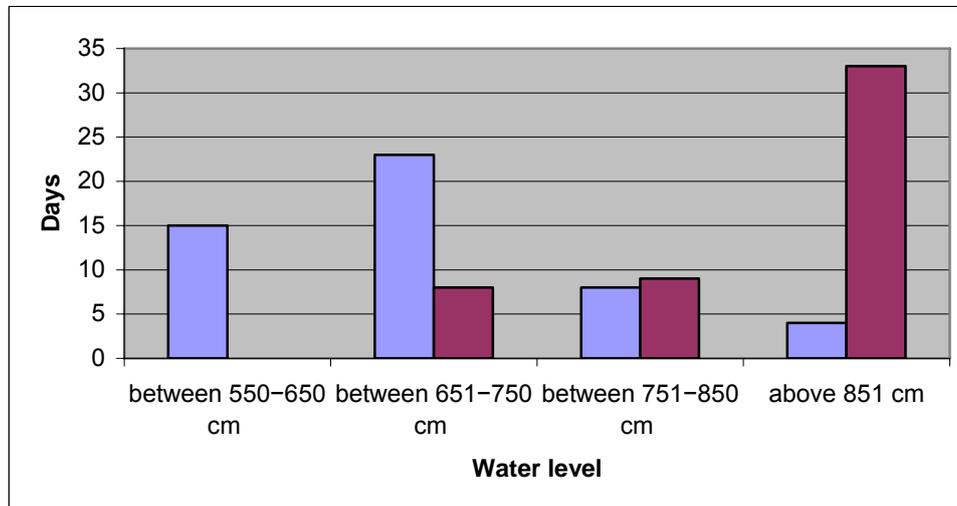


From data of Hydrographical Yearbook, edited by BABÁK K. 2010.

According to the water station of Hármas-Körös River by Gyoma we analysed the whole year of 1919. The water levels were usually between 300–350 cm (9.17%), but typical ranges were also between –50––100 cm, 200–250 cm, –1––50 cm, 0–50 cm, 450–500 cm (together 47%). Consider the flood prevention preparedness system valid in 1919 first level was obtained for 23 days, second level ran for 16 days, third level for 7 days, extra level was needed for 2 days on the water station of Hármas-Körös River by Gyoma.

The flood of 1970 ran for 50 days by Gyoma (*Fig. 7.*), it culminated on 14th of June at 918 cm, it was 45 cm higher than in 1919.

Fig. 7. The distribution of flood-days of Hármas-Körös River in 1970 by Gyoma and Kunszentmárton.



From data of Hydrographical Yearbook, edited by BABÁK K. 2010.

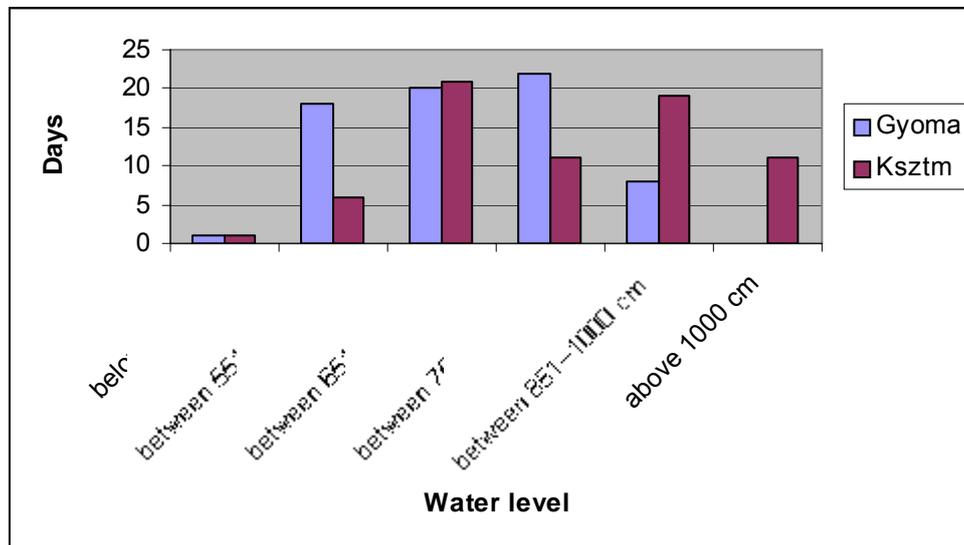
In case of the water station of Hármas-Körös River by Gyoma we analysed the whole year of 1970. The water levels were the usually in the range of 300–350 cm (23.84%), which is lower by 2 meters than the first level of the flood prevention preparedness. The second most often observation was in the range of 350–400 cm (15.89%), in the other sections – 550–600 cm, 450–500 cm, 250–300 cm, 650–700 cm, 600–650 cm – were the 34.24% of the total observations.

The water levels were influenced by the damming effect of Tisza River at Kunszentmárton in 1970, so there the flood took for a lot longer period, it ran for 121 days. The culmination was on 15th of June, that was higher by 47cm than the biggest high water level in 1919. We restricted the distribution of flood days just for that 50 day-long period, when the flood ran by Gyoma. From this 50 days data is missing for the first level of flood prevention preparedness by Kunszentmárton, and the number of the water levels measured above 851 cm are salient high (*Fig. 7.*).

We analysed the whole year of 1970 in case of water station Kunszentmárton. The water levels were usually in the range of 0–50 cm (10.68%). It was followed by the section of 150–200 cm. It took the 7.67% of the researched 365 days. The sum of other ranges (–1—50 cm, 100–150 cm, 700–750 cm, 650–700 cm) took the 29.32% of the case.

The flood in 2006 ran for 69 days at Gyoma. It was 19 days longer than in 1970 (*Fig. 8.*). The flood culminated on 19th of April at 909 cm, there was higher by 36 cm than the top of the food level in 1919, but it stayed below the biggest high water level in 1970 by 9 cm.

Fig. 8. The distribution of flood-days of Hármas-Körös River in 2006 by Gyoma and Kunszentmárton.



From data of Hydrographical Yearbook, edited by BABÁK K. 2010.

The damming effect of Tisza River had influence on the water levels at Kunszentmárton in 2006 – alike in 1970. The flood ran for 75 days, it took only a few days longer than at Gyoma (*Fig. 8.*). The flood culminated on 21st of April at 1041 cm, there was higher by 141 cm than the biggest high water level in 1919, and it was higher by 94 cm than the top of the flood level in 1970. For comparison we restricted the distribution of the flood days to the 69-day-long period, whenever the flood ran by Gyoma.

We analysed the whole year of 2006 according to the water station by Gyoma. The water levels were usually in the range of 300–350 cm (36.44%). (This section was the widest also in 1970.) The second widest section was 500–550 cm, it represented on the 5.75% of the 365 days. Other determinative ranges were –1–50 cm, 0–50 cm, 600–650 cm, 650–700 cm and 750–800 cm, the sum of them took 26.04%.

In case of water station by Kunszentmárton we also analysed the whole year of 2006. The water levels were usually in the range of 0–50 cm (12.60%). (This section was the widest in 1970 again.) The second widest section was –1–50 cm (this is below the „0” point), it represented on the 12.5% of the total year. Other determinative ranges were –51–100 cm, 50–100 cm and 100–150 cm, the sum of them took 26.03%.

- Is it possible to detect similar amount of flood deposit which are in the bank of Mid- and Lower Tisza by the sampling at sight?

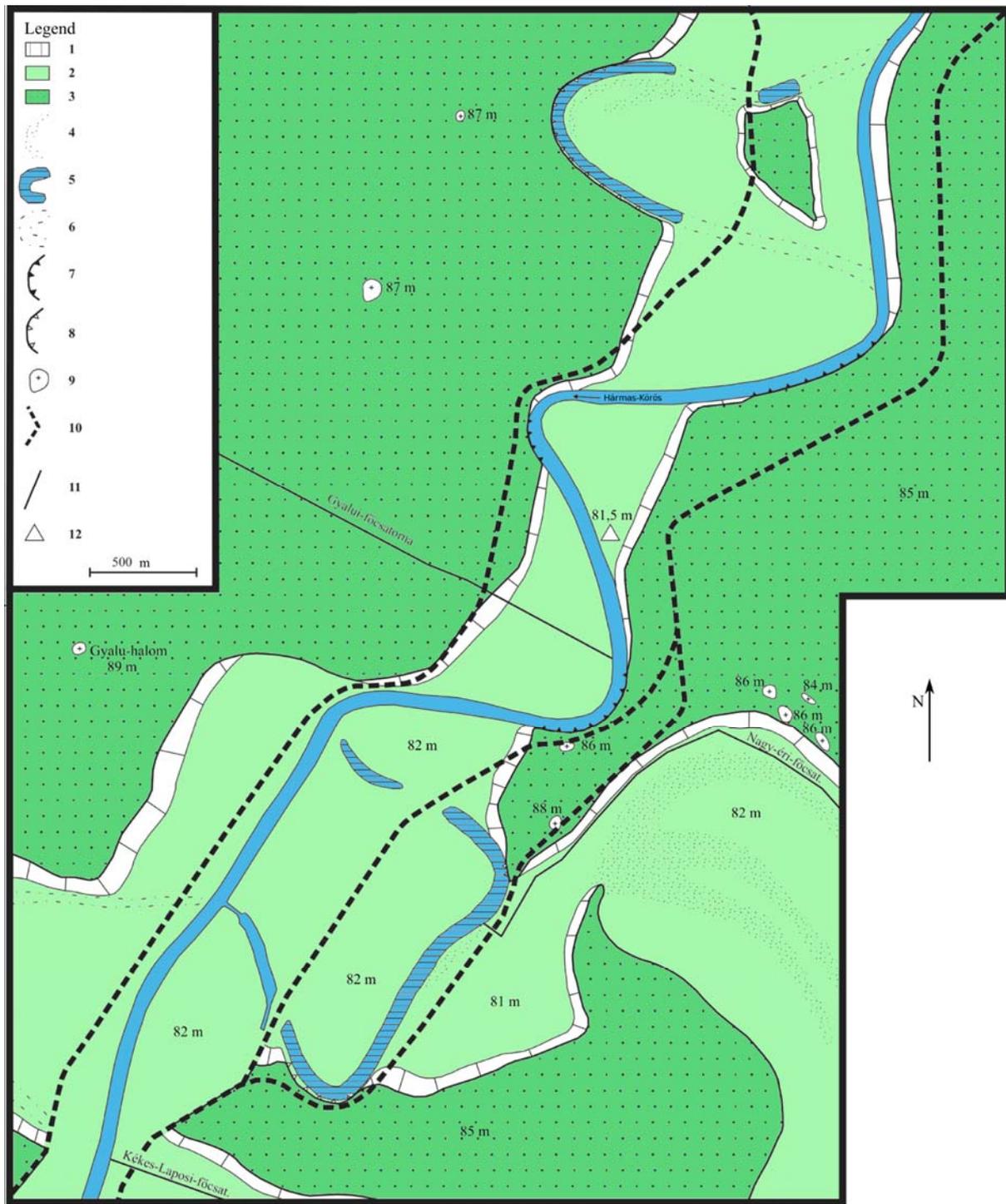
Thesis 5. The amount of flood deposit of Hármas-Körös is consistent with Mid- and Lower Tisza.

Our study area was on the sector of Hármas-Körös River between Öcsöd and Kunszentmárton. The sampling was taken in the valley of Takács-zug. We created our geomorphologic drafts from 1:10 000 scale maps (47–411 Kunszentmárton and 47–413 Öcsöd). We indicated many archive river systems according to the contour lines of the river basins. Nowadays these can be links between flood and inland waters in the active floodplains and these also can be the main fields of the turnout of „buzgár” during a flood (BABÁK K. 2006).

The big part of the mapping field is high floodplain. Into this a slanting low floodplain is deepening with 3–5 meters deep margin. That is supposedly an old derelict riverbed of a previous bigger river. The Körös River built out its own floodplain on this low floodplain with meandering between the margins and also breaking down some of them. Sampling showed that the thickness of the flood deposit was in 150–180cm range along the Hármas-Körös River’s floodplain which was not excavator pit neither point bar.

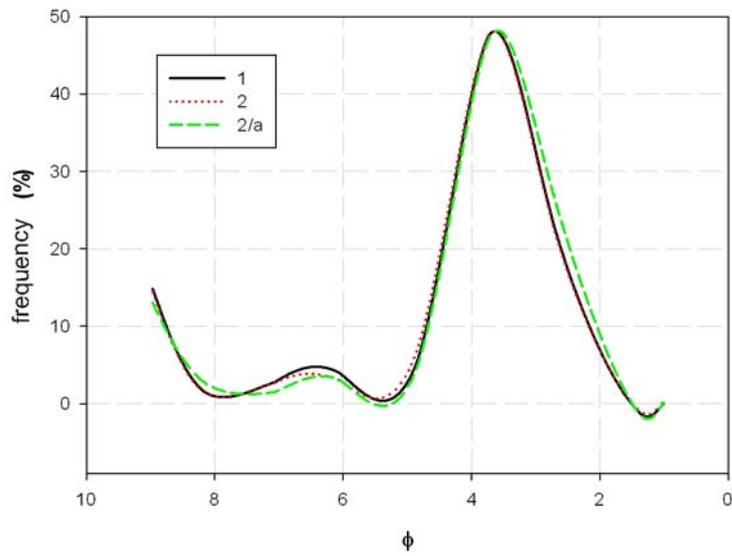
We have allocated our sediment samples applying the particle content, than we categorized them by the modality of two groups. The first type was the unimodal (the samples numbers of 1., 2. and 2/a), which showed the geological meaning of a process (carrier fluid) (*Fig. 9.*). The carrier fluid was very probably the river itself. The types of sediments (the samples of 1., 2., 2/a) were soft and very soft sand (2–4 ϕ). The other group (the samples numbers of 3–10) could be described by plots with several modus which were bimodal sediments in our case (*Fig. 10.*).

Map 1. Simplified geomorphological map of the study area between Öcsöd and Kunszentmárton along the Hármas-Körös River (modified BABÁK K. 2006).



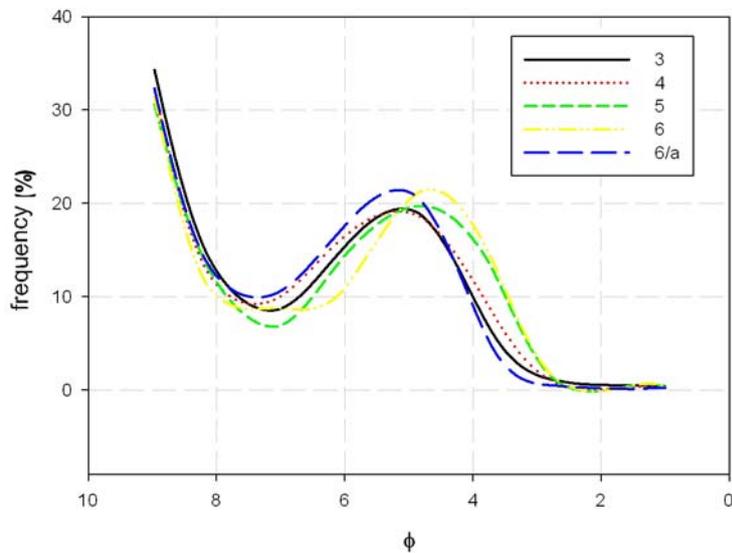
1 = slope; 2 = low floodplain; 3 = high floodplain; 4 = point bar; 5 = oxbow lake; 6 = fossil meander;
 7 = active precipitous low riverbank; 8 = inactive precipitous low riverbank; 9 = kurgan; 10 = embankment;
 11 = channel; 12 = sampling point

Fig 9. The granulometric curves of the samples numbers of 1., 2. and 2/a in Takács-zug of Hármas-Körös River.



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Fig. 10. The granulometric curves of the samples numbers of 3., 4., 5., 6., 6/a in Takács-zug of Hármas-Körös River.



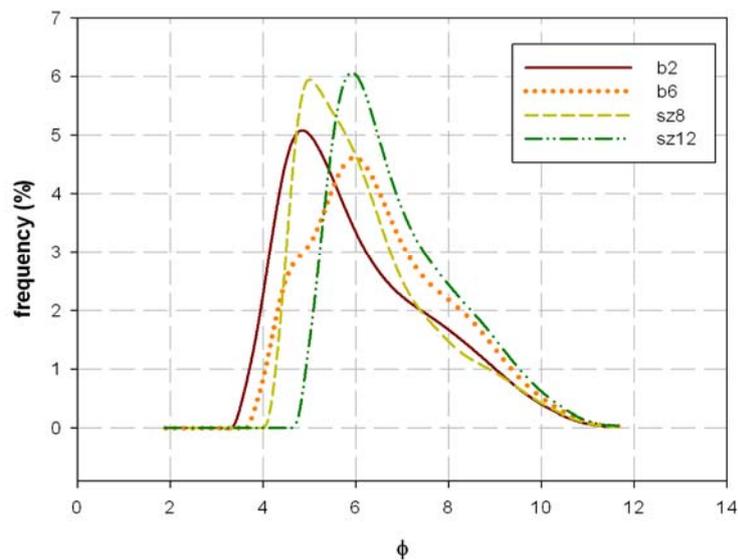
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In July of 2007 – exactly after one year of the big spring flood in 2006, we made field trip and sediment sampling in the border of Szelevény and in 200 meters distance from the Damm and Lock in Békésszentandrás. In the course of the sampling in Szelevény we separated 12 levels. According to these levels we numbered our samples from the bottom to the top. We collected 12 samples in Szelevény and 6 samples in Békésszentandrás.

The common grain size of all the sediments were in the range of 10–25 μm ($5,3\text{--}6,5\phi$), according to the Wentworth-scale it was characterized as soft–medium silt or sediment type. The maximum of frequency were also in the range of 14–63 μm ($4\text{--}6\phi$), which meant the grosser sediment type of silt fraction. The grossest particles of the sediment samples could be typified with maximum 3ϕ value, which was in the very soft silt and sand fraction. The softer particles of the sediment ($7\text{--}12\phi$) were in the very soft silt and clay fraction. These values meant a soft particle of the floodplain sediment type.

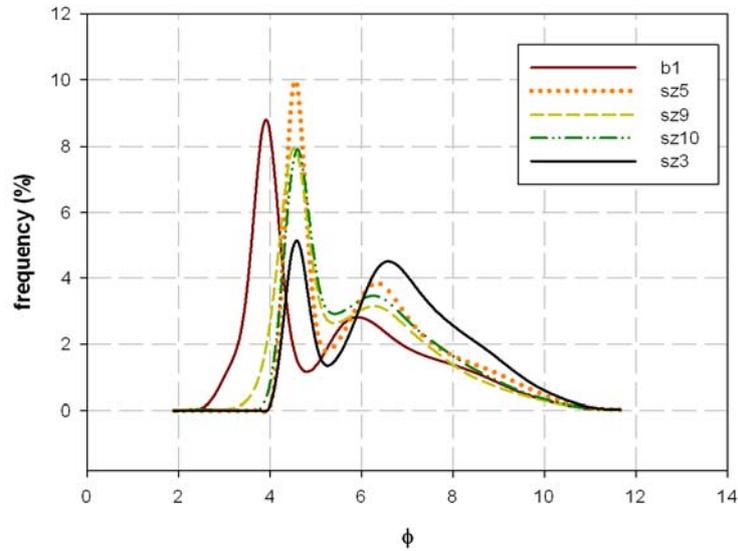
Our sediment samples could be categorized according to modality to two groups. The first type is the unimodal (the samples numbers b2, sz8, sz12 and partly b6), which showed the geological meaning of a process (*Fig. 11.*). The other group could be described by plots with several modus which were bimodal sediments in our case (*Fig. 12.*).

Fig. 11. The unimodal sediment samples of b2, the b6, the sz8 and the sz12.



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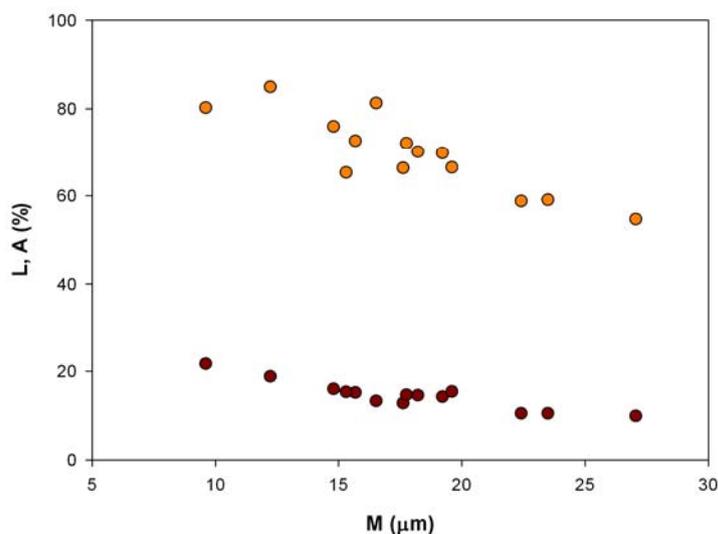
Fig. 12. The bimodal sediment samples of the b1, the sz5, the sz9, the sz10 and the sz3.



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For the identification of accumulation we used the Passega LM and AM plot (PASSEGA, R. 1964, BRAVARD, J. P. – PEIRY, L. 1999). The extension of Passega CM plot to the silt and clay sediments were based on the comparison of the LM and AM parameters. The M value was the median in micrometer and below the L=31 μm and the A=4 μm were the total fraction of in % value. According to the two diagrams (*Fig. 13.*) the sediments were typical flood deposits versions (BRAVARD, J. P. – PEIRY, L. 1999), which were deposited far away from riverbed in the stagnant water.

Fig. 13. The Passega AL–M plot.



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Since the river regulations height of the dikes is raised continuously at the Tisza River system, despite it happened several times that the high flood level achieved or passed the top of the dikes. Originally the dikes were built to protect from the high water calculated of the one-in-every 50 years occurrence. But these dikes have to be stilt again and again because of the continuous deposition of the active floodplain. Provisionally the river will flow higher than the low floodplain of the flood immunization which was usually under water during floods as a result of the continuous deposition of the active floodplain. In this way the Tisza River will not flow in the valley, in the deepest place, but it will do it on the height on ridge of the deposited and stilted active floodplain and the water will not be able to regurgitate into the high-seated riverbed. It is not extreme to consider that sooner or later the Tisza River and the tributaries which are flowing on the Hungarian Plain will have the same fate as the Po River where the low water of the river is higher than the top of the houses in Ferrara.

The further research direction

To be able to compare and analyse in a wider range our data we got during our mathematical-statistical researches we have to amend our database of 100 years time interval (1907–2006) with the following water stations: on the Fehér-Körös River in Gyula, on the Fekete-Körös River in Remete, on the Sebes-Körös River in Körösszakál, on the Kettős-Körös River in Békés and on the Berettyó River in Szeghalom. From these data we make conclusions about the other members of the river system if they have similar or completely different tendencies than Hármas-Körös River in point of regime.

I consider important the detailed representation and analysis of different attitudes of least three extreme floods on the Fehér-, Fekete-, Sebes- and the Kettős-Körös River (frequency, permanency, the interval of flood, the level of the flood prevention preparedness, etc.)

Extending our geomorphologic mapping and sampling to the whole water system it can provide several guidelines in the future to get more information about deposition method on the floodplain of the Körös Rivers if it is similar, less or grater than at the Tisza River.

1. References

1.1. Published literature related to PhD topic

- 1) **BABÁK K.** 2010. *Alföldi folyóink ártérfejlődési kutatásai a XX. század elejétől napjainkig.* – **Hidrológiai Közlöny**, 90. évfolyam, 4. szám, pp. 42–48.
- 2) **RADVÁNSZKY B.** – **BABÁK K.** – **BALOGH J.** – **FÁBIÁN SZ. Á.** – **SCHWEITZER F.** (közlésre elfogadva). *A Tisza vízgyűjtőjének árvízvédelmi biztonsága és a klímahatások kapcsolata.* – „**Klíma-21**” Füzetek. Klímaváltozás – hatások – válaszok. No. 60.
- 3) **BABÁK K.** 2009. *The floodplain of Hármas-Körös river.* In: **CARESTIATO, N.** – **GUARAN, A.** (ed): *Water in the Euro-Mediterranean Area II.* (Ambiente e Territorio 22) Forum, Udine, pp. 1–4.
- 4) **BABÁK K.** 2006. *A Hármas-Körös hullámterének feltöltődése a folyószabályozások óta.* – **Földrajzi Értesítő**, LV. évfolyam, 3–4. füzet, pp. 393–399.
- 5) **BABÁK K.** 2006. *A Körösök menti települések árvízi veszélyeztetettsége.* In: **FÜLEKY GY.** (szerk.): *A táj változásai a Kárpát-medencében. Település a tájban.* Környezetkímélő Agrokémiáért Alapítvány, Gödöllő, pp. 158–161.
- 6) **BABÁK K.** 2006. *Hullámtérfeltöltődés: árvizek és belvizek.* In: **SZENTMARJAI D.** – **TÓTH J.** (szerk.) *Geográfus Doktoranduszok VI. Országos Konferenciája*, Pécs, 2001. november 21–23. Természetföldrajz szekció. Pécs, PTE TTK FI, pp 1–8. CD-kiadvány.
- 7) **BABÁK K.** – **FÁBIÁN SZ. Á.** 2005. *Természeti veszélyek és a geomorfológia.* In: **BUGYA T.** – **WILHELM Z.** (szerk.): *Tanulmányok Tóth Józsefnek.* Pécs, PTE TTK Földrajzi Intézet, pp. 127–138.
- 8) **BABÁK K.** 2004. *A magyar vízügyi törvények a kezdetektől napjainkig.* In: *Geográfus Doktoranduszok VIII. Országos Konferenciája*, Szeged, SZTE Természeti Földrajzi és Geoinformatikai Tanszék, pp. 1–10. CD-kiadvány.
- 9) **BABÁK K.** 2004. *A „Vásárhelyi-terv” a XXI. században.* In: **FÜLEKY GY.** (szerk.): *A táj változásai a Kárpát-medencében. Víz a tájban.* Környezetkímélő Agrokémiáért Alapítvány, Gödöllő, pp. 93–97.
- 10) **BABÁK K.** 2004. *Az Európai Unió víz keretirányelve.* In: **BABÁK K.** – **TÓTH J.** (szerk.) *Földrajzi tanulmányok a pécsi doktoriskolából IV.* Pécs, PTE TTK FI, pp. 5–15.
- 11) **BABÁK K.** 2002. *A hullámterek bővítésének szükségessége a Tisza magyarországi vízrendszerében.* In: **FÜLEKY GY.** (szerk.): *A táj változásai a Kárpát-medencében. Az épített környezet változása.* Környezetkímélő Agrokémiáért Alapítvány, Gödöllő, pp. 85–87.

1.2. Conference presentations related to PhD topic

- 12) **BABÁK K.** 2010. *The regime of Hármas-Körös river between 1907–2006.* 13th European Seminar on Geography of Water. “Community Scale Water Management patterns in Transylvania”. Cluj-Napoca, July 4–15, 2010, 1 p.
- 13) **BABÁK K.** 2009. *A Berettyó–Körösvidék a negyedidőszakban.* In: FÁBIÁN SZ. Á. – GÖRCS N. L. (szerk.) 100 éves a jégkorszak. A jégkorszaki klímaváltozások hatása Penck–Brücknertől napjainkig (1909–2009). Pécs, 2009. október 1–3, p. 12.
- 14) **BABÁK K.** 2008. *The alluvial deposits of flood-plains of Körös river during the river control.* 9th International Symposium on Instrumental Analysis. Pécs, p. 52.

2. Other publications, presentations

1.1. Published literature

- 1) WILHELM Z. – **BABÁK K.** 2010. *Regionális különbségek vizsgálata Indiában, a SENTIENT Index alkalmazásával.* In: KOVÁCS I. P. – TRÓCSÁNYI A. (szerk.) Tér – Talentum – Tanítványok I. Publikon Kiadó, Pécs. (megjelenés alatt)
- 2) **BABÁK K.** – GÁLOSI-KOVÁCS B. – FODOR I. – PISZTER G. – RONCZYK L. – WILHELM Z. 2009. *Régi válasz új kihívásokra – a vízbázisvédelem lehetőségei Indiában.* In: FÁBIÁN SZ. Á. – KOVÁCS I. P. (szerk.) Az édesvízi mészkövektől a sivatagi kéregkig. Tanulmánykötet a 70 éves Schweitzer Ferenc tiszteletére. PTE TTK Földrajzi Intézet, Pécs, pp. 61–80.
- 3) **BABÁK K.** 2009. *Hír- és távközlés, információs gazdaság.* In: REMÉNYI P. – TÓTH J. (szerk.): Az Ormánság helye és lehetőségei. Az Ormánság társadalmi-gazdasági viszonyainak komplex feltárása. IDRResearch, Pécs, pp. 205–231.
- 4) **BABÁK K.** – RAVAZDI L. 2008. *A lakossági vízfogyasztás kérdőíves felmérésének tapasztalatai Bábaapáti környékén.* In: FODOR I. (szerk.) A fenntartható fejlődés környezetvédelmi összefüggései a Kárpát-medencében. KVVM, MTA Pécsi Területi Bizottság, MTA RKK DTI, Pécs, pp. 184–189.
- 5) FÁBIÁN, SZ. Á. – KOVÁCS, J. – LÓCZY, D. – SCHWEITZER F. – VARGA, G. – **BABÁK, K.** – LAMPÉRT, K. – NAGY, A. 2006. *Geomorphologic hazards in the carpathian foreland, Tolna county (Hungary).* – *Studia Geomorphologica Carpatho-Balcanica*, Vol. 40, pp. 107–118.
- 6) **BABÁK K.** – RAVAZDI L. 2002. *A szarvasi szlovák kisebbség helyzete napjainkban és kapcsolata Szlovákiával.* In: SZÓNOKYNE ANCSIN G. (szerk.): Határok és az Európai Unió, Szeged, pp. 169–174.