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EFFECTS OF FITTING WORKS AND OF WATER FACILITIES ON RUNOFF WITHIN TIMIŞ-BEGA HYDROGRAPHICAL SYSTEM (ROMANIA)

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Abstract: Timiş-Bega hydrographical system is an area located in the western part of Romania and includes the hydrographical basins of the transboundary rivers: Timiș and Bega, which are the most important rivers from Banat region. This region has a complex hydrotechnical scheme and includes all hydrotechnical techniques and several types of hydrotechnical works. The antropic factor has a great influence on runoff within Timiş-Bega hydrographical system and the main hydrotechnical works realised in this hydrographical area cause changes in the natural runoff, especially in the maximum runoff, which causes frequent floods. These fitting works have a positive influence on the mitigation of flood waves, which justify their beneficial role especially in the last catastrophic floods, produced in 2005 and 2000 because they reduced the flash flood peaks carried by both rivers (Timiș and Bega) and reducing the damages. All the antropic changes made within Timiş-Bega hydrographical system are important because they have a positive influence on the mitigation of flood waves, which justify their beneficial role especially in the last catastrophic floods.

Keywords: Timis-Bega hydrographical system, water resources management, fitting works, water facilities, runoff, floods

1. INTRODUCTION

Timiş-Bega hydrographical system is an area located in the western part of Romania, overlapping the hydrographical basins of Timiș and Bega rivers, named after the hydrotechnical fittings constructed in the two basins, meant to ease the better management of the water resources within them, interconnecting the two rivers, meaning the Coştei-Chizătău supply channel and Topolovăţ-Hitiaș discharge channel (Arba, 2016).

This hydrographical system is one of the most important hydrographical basins from Banat region, situated in the south-western part of the country and which benefit from the first hydrotechnical developments executed in our entire country.

Starting from 1716 and up to the present, the antropic factor has influenced the runoff within this basin, by achieving hydrotechnical fittings, among which the most important are: the regulation of maximum discharges on the main rivers and the most important tributaries, the performance of flood mitigation works and river bed regulation, damming works on the most important rivers and tributaries, within the proximity of the most important localities (Munteanu, Harabagiu, 2001-2002, Dunca, 2017).

Banat region has a complex hydrotechnical planning as a result of a long-term water resources management activity that begins 300 years ago with the great plan of the zone's reorganization initiated and executed by the imperial administration from that period (Olaru, 2006, Dunca, 2017).

For the economic development and the profitability of Banat region, for the drainage of the marshes, but also for the transport of wood and agricultural products, in the year 1716, there was a request for the realization of a water resource management activity in this hydrographical area, with the help of a sustained hydrotehnic control plan, which respects the principle of mastering and multilateral use of water, of some hydraulic structures and of a more and more hydrotehnic control scheme (Dunca, 2017).

This plan involved the construction of some hydrotechnical works on the main watercourses (e.g. Timiș and Bega) and the shaping more and more complex hydrotechnical scheme with a very important role in the formation and influence over the natural processes of runoff within the main hydrographical basins.

At the present the hydrotechnical scheme of Timiş-Bega hydrographical system is particularly complex and includes all techniques and several types of works like as: hydrotechnical works for the regulation of the maximum runoff and the mitigation of the floods waves (embankment works, permanent storages and non-permanent storages) and river's engineering and shore embankment works of the main rivers (Dunca, Bădăluță-Minda, 2017).

The regularization of major watercourses, embankments, drainage works, connection channels between Timiș and Bega rivers, plus the many uses of Timiș waters and of his tributaries, cause changes in the natural runoff within hydrographical basins, especially in the maximum runoff, which is responsible for the frequent floods occurred.

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2. TYPES OF FITTING WORKS

Nowadays Banat region has a complex hydrotechnical scheme and includes all techniques and several types of hydrotechnical works. The hydraulic structures carried out in Banat have focused on Timiș and Bega rivers and also on their main tributaries because these two rivers are the largest and the most important rivers from this region which contributed in the past to the excees of humidity in the low area and to the occurence of frequent and intense floods.

The most important types of hydrotechnical works realized in Timiş-Bega hydrographical system are: hydraulic structures for the regulation of peak discharge and mitigation of floods waves for the purpose of defending against floods and reducing the negative effects that these extreme hydrological phenomena might have, and the regulation hydraulic structures of some river beds and embankment of the largest banks flowing waters in the perimeter of the most important cities and rural areas (Dunca, 2017).

A very important role in the hydrotechnical scheme of Timiş-Bega hydrographical system is played by the connection between the two main rivers, meant to ease the better management of the water resources within them (Coştei-Chizătău supply channel and Topolovăţ-Hitiaş discharge channel).

The floods defense activity in the valley of Timiş and Bega rivers started in the middle of the 19th century, as well through the embankment of the main rivers and their main tributaries.

Later in order to complete the flood control system in Timiş-Bega hydrographical system, it was necessary to carry out several permanent and non-permanent storages with an important role in the hydrotechnical control scheme of this region (Dunca, Bădăluță-Minda, 2017).

The permanent storages from this region are made on the watercourses in the upper waters of hydrographical basins, with the primary role of retaining a portion of the flood wave's volume discharging through rivers, attenuating the runoff from downstream and the non-permanent storages are damming surfaces in a major river bed, designed to attenuate the flood waves (Dunca, 2017).

The main permanent storages realized in Timiş-Bega hydrographical basin are: Trei Ape (Timiș), Rusca (Râul Rece), Poiana Mărului (Bistra Mărului), Zerveşti (Sebeş) and Surduc (Gladna).

The most important non-permanent storages made in this hydrographical basin to attenuate the flood waves are: Hitiaş (Timiş and Bega rivers), Cadar-Duboz (Pogăniş), Pădureni (Timiş), Gad (Lanca Birda) and Pişchia (Bega Veche).

All the antropic changes made within Timiş-Bega hydrographical system in the last three centuries are very important because they have a positive influence on the mitigation of flood waves, which justify their beneficial role especially in case of hydrological risk phenomena such as the last catastrophic floods, produced in 2005 and 2000.

3. TYPES OF WATER FACILITIES

The use of water resources from Timiş-Bega hydrographical basin is comprised within two large use categories, as follows:

- facilities that do not consume water (hydro-power plants and recreational areas);
- facilities that consume water (industry, agriculture, drinkable water supply of the population and aqua-farming) (Arba, 2016);

The rivers of Timiş-Bega hydrographical space are used in the following purposes:

- sewerage works and water course regulation works on the sector of confluence of Timiş-Bega supply channel - on the Romanian border with Serbia;
- water derivation works from Timiș river into Bega Channel and vice-versa through the means of Timiş-Bega interconnection, with various purposes;
- water supplies: Timiș river, Bega river and their tributaries;
- hydrological improvement works in the area of Timiș-Bega interconnection, with the purpose of flood protection of a land surface of about 226,000 ha;
- damming works on the main rivers (Timiș, Bega and the most important tributaries) on their middle and lower courses;
- derivation hydrotechnical knots; Coștei (on Timiș) and Topolovăț (on Bega), with an important role in the water supply and the prevention of floods for Timișoara;
- separation hydrotechnical knots: Hydro-power plant (HPP) Timișoara, with a role in the drinkable and industrial water supply of Timișoara during the average and low waters (Árpád, 2010);
- navigation and separation hydrotechnical knots: Sânmihaiu Român and Sânmartinu Maghiar;
- hydro-energetic: M.H.C. Constantin Daicoviciu and M.H.C. Surduc;
- navigation: Bega Channel;
- recreational: Bega Channel and Valea lui Liman;
- extraction of construction materials (gravel plants): on Timiș and Bega rivers (Arba, 2016);

The permanent and impermanent storages, built within the basin for various purposes, are used within several branches that consume water, as follows: drinkable and industrial water supply, hydro-energetic, protection against floods, irrigation, agricultural and fishing stock purposes, recreational lakes and complex use, for several facilities.

The main purposes for which most of the permanent storages of the basin have been commissioned are: the assurance of the water reserve for the upstream localities and the supplementation of discharges in low waters, the exploitation of the hydro-energetically potential of the waters and the reduction of the flash flood waves during the periods with high waters.

Some of the existing artificial lakes in the basin serve for the supply of the water resources in the

rivers that are used within the Şag-Topolovăţ irrigation system, for the irrigation of a significant surface of agricultural land.

Moreover, there are several ponds in the basin, among which the most important are the ones from the following localities: Bacova, Nițchidorf, Sacoșu Turcesc, Icloda, Giroc, Chișoda, Liebling, Topolovățu Mare, Șuștra, Ianova, Ghiroda, Săcălaz, Herneacova and Timișoara.

Besides all these purposes, the existing permanent storages in the basin are used for a tourist purpose, representing the recreational lake (Trei Ape and Surduc), where fishermen and recreation lovers can rejoice in the natural environment (Arba, 2015).

4. CASE STUDIES

The analysis of the annual average discharge of water from Timiş-Bega hydrographical system, in fitted regime, has been performed by analysing the re-enactment of the natural discharge in several control sections for the period 1968-2012, meaning all the hydrometrical stations situated on the course of Timiş river (Teregova, Sadova, Caransebeş, Lugoj, Brod and Şag) and on the course of Bega river (Balinț, Chizătău, Topolovăț and Remetea) (Dunca, Bădăluță-Minda, 2017).

The general evaluation of the discharge in fitted regime, from this hydrographical basin, reveals a close connection between: the K coefficients, the correction discharges and the water volumes consumed by the facilities. The years in which the K coefficients had the lowest values, the correction discharge share exceeded 5% and the consumed water volumes were among the highest are those years when no compensation of the minimum discharges was performed, due to the lowest discharges measured than the natural discharges and the multiannual average natural ones (Arba, 2016).

Comparing the strings of annual average natural discharges and the one re-enacted from the analysed period, from the above-mentioned hydrometric stations, we have noticed that their variation is different, identifying for each of the analysed stations, a real influence of the hydrotechnical works achieved within the basin and of the water-consuming facilities on the average water discharge on the two main rivers (Timiş and Bega).

In the studied hydrographical space, the effects of the hydrotechnical fitting works and of the water facilities on the annual average, maximum and minimum discharge have manifested on the entire analysed period, from the first year of re-enactment of the discharges and until 2012, noticing significant differences between the recorded discharges and the re-enacted discharges.

We have noticed that, as we move further from the two river springs, the changes induced by the existing hydrotechnical works upstream and by the water-consuming facilities, especially in the field of water supply of the population, of the industry and of agriculture (irrigation), on the natural discharge regime and that, in general, the Bega river is much more influenced from this point of view, compared to Timiş river.

The hydrological risk phenomena like as floods may have strong negative effects in Banat region because the frequency of major floods is of about 30 years with a few exceptions when these risk phenomena occur every few years as is the case with floods occurred in 2000, followed by the ones in 2005 (Arba, 2010).

In order to reduce the negative effects of the hydrological risk phenomena like are floods which may occur within Timiş-Bega hydrographical system more hydrotechnical works have been done in the last three centuries, with an important role on the regulation of maximum runoff and mitigation of flood waves which may occur.

The parameters of the flood from April 2000, measured and re-enacted, are especially important in the evaluation of the role that the physical and geographical factors had in the occurrence and the propagation of the flood wave, but also in finding the potential errors that could have occurred in the analysis of this extreme hydrological phenomenon.

The flash flood wave from April 2000 suffered a natural reduction, as well as an artificial one through the retention or the loss of a significant water volume. The water retention was achieved through the use of existing hydrotechnical works, as follows:

- Poiana Mărului reservoir retained 11.2 mil. m^3 of water;
- Surduc reservoir retained 10.3 mil. m^3 of water;
- Hitiaş temporary reservoir retained 8.42 mil. m^3 of water (6.93 mil. m^3 from Bega and 1.49 mil. m^3 from Timiș);
- Pădureni temporary reservoir retained 14.0 mil. m^3 of water;
- Cadar Duboz temporary reservoir retained 21.5 mil. m^3 of water;
- Gad temporary reservoir retained 7.0 mil. m^3 of water (Aldescu, 2010).

All the existing hydrotechnical works in this hydrographical system had a beneficial influence on the flood from 5-11 April 2000, reducing the flash flood peak carried by both rivers (Timiș and Bega) and reducing the damages.

The flash flood from April 2005 is the most recent extreme hydrological phenomenon that took place in Timiş-Bega hydrographical space, which was triggered by the significant quantity of atmospheric precipitations that fell in the respective month (Teodorescu, 2006).

The water volume stored in the permanent and temporary reservoirs during the flood from April 2005 was of 131.09 million. m^3, calculated for the closing section at the border.

The flash flood wave was one with devastating consequences in some regions within the basin. Following the occurrence of these successive waves, Timiş river waters overflew and led to the breakage of the embankment from the right bank, in the area of Crai Nou locality and to the flooding of tens of hectares of land and of several localities (Nichita et al., 2006).

In this flood case the competent institutions using the existing hydrotechnical fittings, took the following measures during the flash flood: emptying the deposits of the reservoirs, the defence stock verification, the interception of the flash flood waves in the volume parts available in the permanent and temporary reservoirs, the derivation and the blockage of the flash flood waves through the two derivations and the temporary over elevation of the sand embankments (Report on the flash flood from April 2005 in Banat hydrographical space, 2005).

Although the occurred flash flood was an extraordinary one, causing the excess of the transport capacity of the river beds due to the fact that the defence damming works were sized for a flash flood with an occurrence probability of once every 20 years, all the existing hydrotechnical fitting works from the region had an especially important role in the reduction of the flash flood wave and in the reduction of the damages caused, and the measures taken had as a result the reduction of the flood waves with 20-30 % (Arba, 2009).

To prevent the negative effects that can be caused by floods in this hydrographical space after the flood from 2005, the following measures were taken: the over elevation works at the temporary earth embankments were completed on the existing embankment and the fitting works on Timiș river, as well as the discharge regulation works were continued (Arba, 2016).

The temporary dams can ensure a protection against the overflow until the reaching of the second phase of defence, and, in case of necessity, the temporary dams shall be elevated with geotextile bags (Report on the flash flood from April 2005 in Banat hydrographical space, 2005).

5. CONCLUSIONS

In order to reduce the negative effects of the hydrological risk phenomena like are floods which may occur within Timiş-Bega hydrographical system more hydrotechnical works have been done in the last three centuries, with an important role on the regulation of maximum runoff and mitigation of flood waves which may occur.

The regularization of major watercourses, embankments, drainage works, connection channels between Timiș and Bega rivers, plus the many uses of Timiș waters and of his tributaries, cause changes in the natural runoff within hydrographical basins, especially in the maximum runoff, which is responsible for the frequent floods occurred.

All the existing hydrotechnical works in this hydrographical system had a beneficial influence on the floods 2000 and 2005, reducing the flash flood peaks carried by both rivers (Timiș and Bega) and reducing the damages.

However the last floods occurred in Timiş-Bega hydrographical system has emphasised the need to re-evaluate the necessary protection measures against floods within this basin and the need to improve the cross-border relation between Romania and Serbia, which have transboundary rivers (Timiş şi Bega) and regarding the management activity of crisis situations during the flash floods.

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