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IMPROVING WATER MANAGEMENT OF THE DRAINAGE SYSTEMS FOR ENVIRONMENTAL PROTECTION

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ABSTRACT

The results and considerations in this paper are pointing out the importance of hydrometric measuring, as permanent and indispensable process based on which the hydraulic review of drainage system is achieved. Unquestionably, these investigations are significant, the first of all for environmental protection, which demands constant value of designed functional parameter for facilities of drainage system. The results of hydrometric measuring on drainage system, under the climatic conditions in Voyvodina, are presented on this paper. Measuring is done on the main channel of Plavna drainage system. The discharges are measured, and rough coefficients are determined.

KEY WORDS:
*drainage, environmental protection,
hydrometric measures, channels.*

1. INTRODUCTION

Appropriate dimension and condition of channel network of drainage systems enables proper collection and drainage of excessive water at the right moment. During the construction of this part of drainage system it is necessary to optimise earthworks and to consider the effectiveness of channel network.

If the maintenance of channels is irregular or inadequate, planned functions can be lost (for example, leaking and accepting ability is smaller), which can provoke variety of irregular functions of drainage systems [1, 2].

For technical and economical analysis of drainage system effectiveness, it is necessary to take hydraulic calculations. However, in Voyvodina today there are not enough of available data about geometry, roughness, depth of flow and other foundations, because, unfortunately, there are no suitable measuring. Only by measuring objects and equipment placed on drainage systems, it is possible to achieve correct and instantaneous values of hydraulic coefficients (roughness of channel, overflowing, flowing, losses on covers, grates etc.). This is the way to get precise data, which enables us to calculate the exact discharges and levels of water, and only after this, it is possible to improving water management of the drainage systems for environmental protection.

2. MATERIAL AND METHODS

Researches are carried out on Plavna drainage system, which is located in melioration area of the Danube river in Voyvodina. Drainage surface is 12050 ha, fields are 7800 ha, orchards and vineyards are 120 ha, meadows and pastures are 480 ha and what is left is 3650 ha. Geomorphologic units are alluvial terrace on 1230 ha and alluvial surface of the Danube on 10820 ha.

Types of the ground are chernozem 1460 ha, black soil 5860 ha, alluvial argillaceous ground 4600 ha and others 130 ha. Total length of channel network is 196.4 km, drainage module is 0.50 l/s/ha, recipient of excessive water is the Danube on 1324 km of its length.

There are two drainage stations in the system: Plavna II and I. Plavna I is built in 1912 with total capacity of 5.00 m^3/s (2x2.50 m^3/s) with two pressing tubes Æ 1.30 m and two siphons Æ 1.30 m.

Plavna II is built in 1972 with total capacity of 7.75 m^3/s (2x3.50 m^3/s and 1x0.75 m^3/s) with two pressing tubes Æ 1.20 m and with one sluice gate. There are 172 culverts and bridges.

The length of the main Plavna channel is 10.0 km, with the bottom width of 7.00 m, side slopes are 1 to 2, depth of flow 2.35 m, bottom slope is 0.05 ‰, Manning's roughness coefficient is 0.034 and total discharge is 7.75 m3/s.

Hydrometric measuring is done in July 2002 with fully developed aquatic vegetation and steady uniform flow regime.

Morphologic characteristics of main channel of Plavna is achieved as a result of geodetic surveying by method of geometric nivelman and polar method. Locations of cross sections along the channels are defined by measuring with steel ribbon and elevation of cross sections by the Carl Zeiss Jen NI 025 instrument.

Hydraulic characteristics of main channel of Plavna is achieved by velocity-area method. Current meters for flow measurement AOTT 60663 is the instrument used for velocity measuring.

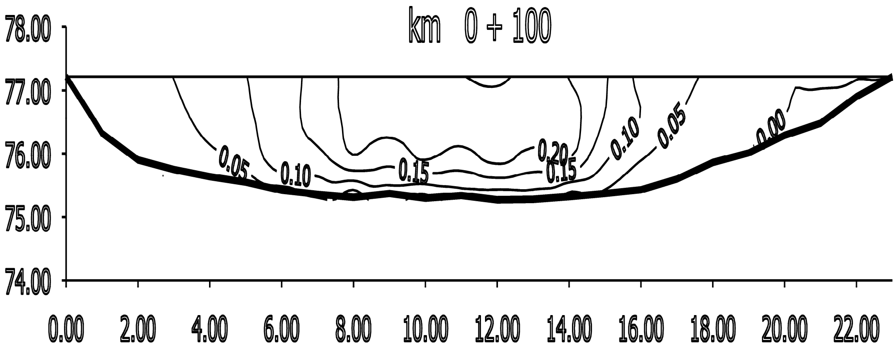
3. RESULTS AND DISCUSSION

According to morphological measuring of cross sections at chosen locations of main Plavna channel it is established:

- at section 0+100 km bottom elevation is 75.19 m, or 1.60 m above projected elevation of 74.13 m;
- at section 0+300 km bottom elevation is 75.00 m, or 0.86 m above projected elevation of 74.14 m.

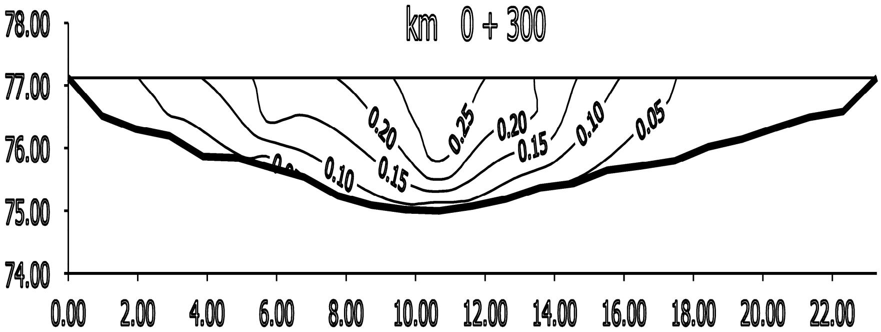
According to geodetic surveying it is established that there are significant differences among measured and projected cross sections. It can be assumed that those differences are the consequence of erosion and deposited sediments.

Elevation (m)



Station (m)

Elevation (m)



Station (m)

FIGURE 1. CURVES OF EQUAL VELOCITY IN MAIN CHANNEL OF PLAVNA DRAINAGE SYSTEM.

Hydraulic characteristics of the main Plavna channel are explored by velocity-area method, which is based on the plan of isotachs of cross section, in other words, on the lines with equal velocity.

Based on the plan of isotachs of cross section, tachigraph curves are defined. In dependence of integration on the cross-sectional area or velocity, the discharge is defined by the formula:

$$Q = \int_0^{v_{max}} A\,dv$$

$$Q = \int_0^{A} v\,dA$$

where:
Q - discharge (m^3/s),
v - velocity (m/s); and
A - cross-sectional area (m^2).

According to current meters measuring, at Figure 1 are presented isotachs in main channel of Plavna drainage system.

A key component of predicting discharge at various depths of flow is to be able to calculate the channel roughness coefficient. The discharge at a cross-section can be estimated by Manning's formula:

$$Q = A\frac{1}{n}R^{2/3}S^{1/2}$$

where: Q - discharge (m^3/s),
A - cross-sectional area (m^2),
R - hydraulic radius (m),
S - channel bottom slope
n - Manning roughness coefficient ($s/m^{1/3}$).

The slope and hydraulic radius can be estimated from longitudinal and cross-sectional surveys respectively.

If we know the discarge for a certain water level (Flow Measurement Tool), then it is possible to back calculate a Manning's n value for that discharge. Back calculate the Manning's n value for each cross-section:

$$n = \frac{AR^{2/3}S^{1/2}}{Q}$$

Results of hydrometric measuring of Plavna drainage system are presented in Table 1. Based on two measuring by current meters, discharge has a value of 4.156 m^3/s, and Manning's n is 0.069. Condition of main channel, with the description of riverbed, is presented at Fig. 2.

TABLE 1. RESULT OF HYDROMETRIC MEASURES.

Section	Cross-sectional area	Wetted perimeter	Hydraulic radius	Cross-section average velocity	Discharge	Manning roughness coefficients
L	A	χ	R	v	Q	n
(km)	(m^2)	(m)	(m)	(m/s)	(m^3/s)	($s/m^{1/3}$)
0+100	33.77	23.74	1.42	0.125	4.204	0.072
0+300	31.66	24.59	1.29	0.130	4.107	0.065

Manning's roughness coefficient is a result of hydrometric measuring and it significantly differs from the one adopted in the project. Based on hydraulic measuring, flow conveyance of the main channel is less for 47% to 53%.

Assuredly, not all measuring needed for a complete inspection of drainage system function, are included here. Problem connected to changing of channel's discharge capacity after some period of time, needs to be analysed separately, from the aspect of constructing it and the ways of managing, and also related to sediments transported through channel.

These changes are not always the same, and after some time roughness can become smaller or bigger, in dependence of concrete conditions and quality of water and ground.

One of the most spread changes is overgrowing the banks of the channel by vegetation, which increase the channel roughness and effectively reduce the channel capacity.

For complete analysis it is needed to carry out hydrometric measuring for different flowing regimes and different discharges.

Because of changes in drainage system, measuring must be a continual process, based on which many relevant issues can be determined.

4. CONCLUSION

Determination of the components of drainage system requires both hydrologic and hydraulic computations. A major component of studies related to channel design, water quality assessment, environmental impact and enhancement analysis, is the prediction of stage, discharge, and velocity as functions of time anywhere on a channel.

Environmental aspects of channel engineering often require the prediction of stage, velocity distributions, sediment transport rates, and water quality characteristics, to evaluate the impacts of proposed actions on future channel characteristics.

Based on the research results it can be concluded that during the summer period, flow conveyance of main channel in Plavna drainage system is considerably decrease. This complicates collecting and drainage of excessive water, which can negatively effect the conditions for carrying out agro-technical works and other components of sustainable agricultural production.

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