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Hydraulic conductivity of saturated bed silts in Chotárny channel, ŽO area, Slovakia

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This paper deals with the comparison of two different ways used for determination of saturated hydraulic conductivity values of bed silts located along the Chotárny channel, obtained from field measurements in 2018. The Chotárny channel is one of three selected monitored channels at the ŽO area – the flat lowland with channel network. The permeability of bed silts impacts water flow between surface water in the channel and surrounding groundwater in the scope of their interaction at this area. It is expressed by its value of saturated hydraulic conductivity. The bed silts along Chotárny channel were extracted and obtained by two ways, as disturbed samples and as undisturbed samples. The selection of sampling place was made by thickness of bed silt in the measured profiles. The samples were extracted in three different vertical parts of bed silt – from top, middle and bottom part of bed silt layer. In case of the disturbed samples the empirical formulas based on the grain size analysis were used for determination of saturated hydraulic conductivity value. In case of undisturbed samples was used the falling head method for determination of saturated hydraulic conductivity value. The values of saturated hydraulic conductivity obtained from disturbed samples of bed silts K_d were calculated by using of several empirical formulas: 1. Bayer – Schweiger; 2. Špaček I.; 3. Špaček II.; 4. Hazen I.; 5. Bayer; 6. USBR and 7. Orechova. The results in Table 1 show that the valid values K_d for Chotárny channel in 2018 were from 1.00x10^{-10} to 1.19x10^{-04} m s^{-1}. The recommended formula for calculation of K_d of bed silts by empirical formulas in Chotárny channel, based on criterium of the largest number of valid obtained results, is Hazen I. formula. The values of saturated hydraulic conductivity obtained from undisturbed samples of bed silts K_u were determined according the relation for calculation of average value of saturated hydraulic conductivity (by falling head method in laboratory). These values are illustrated in Table 2. The values K_u for Chotárny channel in 2018 reached values from 7.68x10^{-08} – 4.53x10^{-05} m s^{-1}. All the results from both methods of determination of saturated hydraulic conductivity were compared.

KEY WORDS: bed silts, permeability of bed silts, saturated hydraulic conductivity, disturbed and undisturbed samples, grain size analysis, falling head method

Introduction

Žitný Ostrov (ŽO), Rye Island – Fig. 1a on the left – was created by sediments transport from upper part of the Danube River. This area formed as a flat plain with only small differences in altitude. Its average slope is about 0.25 ‰ and it was one of the reasons for building channel network here. The channel network at ŽO area was built already in the late 19th century with primary aim to drain the wet places of this area. Thereafter its utilization began also to surface irrigation during dry periods and also to groundwater resources regulation in some ŽO localities. The silting up of channel bottom by bed sediments has impact to bottom permeability of channels in time and by this way to interact with surrounding groundwater. This permeability is expressed by the value of saturated hydraulic conductivity of bed silts. Engineering practice often requires the investigation of ground water movement, volumes in storage and computation of the amount of infiltrated water into or from the aquifer. Hydraulic engineers, hydrologists and hydrogeologists have been studying this topic with a variety of conclusions. In the current literature research papers usually focus on a wide variety of saturated hydraulic conductivity related topics. Habtamu et al. (2019) evaluate saturated hydraulic conductivity with different land uses of disturbed and undisturbed soil, Duong et al. (2019) clarify the effects of soil hydraulic conductivity and rainfall intensity on riverbank stability, Říha et al. (2018) present the verification of validity of various published porosity functions and empirical formulae with the use of the experimental data, Wang et al. (2018) present an alternative model to predict soil hydraulic conductivities, Hwang et al. (2017) compare saturated hydraulic conductivities of sandy soils to characterize properties of water retention, Gadi et al. (2017) studied spatial and temporal variation of hydraulic conductivity and vegetation growth in green infrastructures, Hussain and Nabi (2016) used seven empirical formulas to calculate hydraulic conductivity, based on grain size distribution of unconsolidated aquifer materials, Kutílek (1978) or Kasenow (2010)

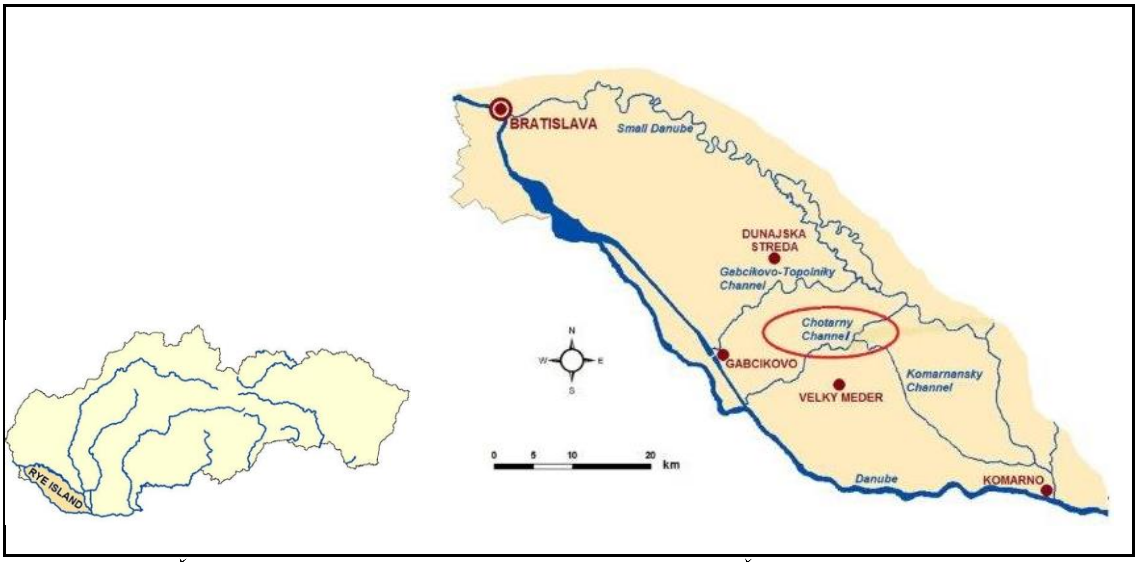

Fig. 1a. ŽO within Slovakia and three monitored channels at ŽO area.

Fig. 1b. Situation of Chotárny channel within the ŽO channel network.

calculated the value of saturated hydraulic conductivity by empirical formulas coming out from grain size analysis, Šurda et al. (2013); Dulovičová et al. (2018) used simplified equipment for measuring of saturated hydraulic conductivity from undisturbed samples by falling head method, etc.

This paper relates to results of field measurements along Chotárny channel – one of three main monitored channels at the ŽO area (Fig. 1a, Fig. 1b). Saturated hydraulic conductivity values of bed silts were determined on the base of two ways of bed silt samples extraction (disturbed and undisturbed samples). The channel network aggradation at ŽO has been monitored and studied by many our regional specialists – Kosorin (1997), Mucha et al. (2006), Štekauerová et al. (2009), Baroková and Šoltész (2014), Kováčová (2017), etc. This paper shows some results of field measurements along the Chotárny channel in 2018 – Fig. 1b.

Material and methods

Chotárny channel is one from three channels of the ŽO channel network monitored by Institute of Hydrology SAS since 1993. Geometrical parameters of this channel observed during the last measurements were: the channel length was approximately 27 km, the channel width was in range 11–17.5 m, the channel depth run into maximal values up to 3.15 m (according to cross-section location). The registered values of hydraulic conductivity in aquifers nearby this channel K_{fs} are 0.40–3.4 x 10^{-3} m s^{-1} (Mišigová, 1988). Chotárny channel receives water from drain channel of Gabčíkovo waterworks. The tributaries of Chotárny channel are channel Gabčíkovo – Ňárad, Čilížsky stream, channel Jurová – Veľký Meder, channel Kračany – Boheľov, Belský channel and Býčí channel. The water from Chotárny channel is used for irrigation by another channels which are connected to this channel network by sluices (Dušek and Velísková, 2014). The collection facility for the Chotárny channel is situated in left-hand embankment of the drain (outflow) channel (in km 1.25) and is permanently closed. Water supply to Chotárny channel is provided by underground seepage pipe. In km 10.15 of Chotárny channel occures the water measuring station Jánošíkovo na Ostrove. The Chotárny channel connects to Little Danube through pumping station eastward of village Topoľníky.

The measurements of bed silt thicknesses along the Chotárny channel in 2018 were performed from the displaceable inflatable boat by simple drill hole. The distance of cross-sections along the channel varied between 1.0–1.5 km. In all channel cross-sections there was measured the water depth and bed silt thicknesses with step 1.0–2.0 m along the channel width. The samples of channel bed silt were extracted in these selected cross-sections where the largest channel bed silt thickness was noticed – in 8 cross-sections of Chotárny channel. Sediment sampling was conducted using the 04.23 Sediment Core Sampler, a rod operated type Beeker. This instrument collected the samples of silts in 1 m long acrylic tube as shown in Fig. 2a.

The Fig. 2b illustrates the sediment sampling from field measurement in one of cross-sections of Chotárny channel.

There was possible to take undisturbed samples of bed silt with this device and from each whole sample there was extracted a part from top, middle and bottom layer of silt. After experimental determination of saturated hydraulic conductivity for each layer of sample from one cross-section, the sample was broken and changed to disturbed sample. Next, for each disturbed sample it was done the granularity analysis and determined the value of saturated hydraulic conductivity.

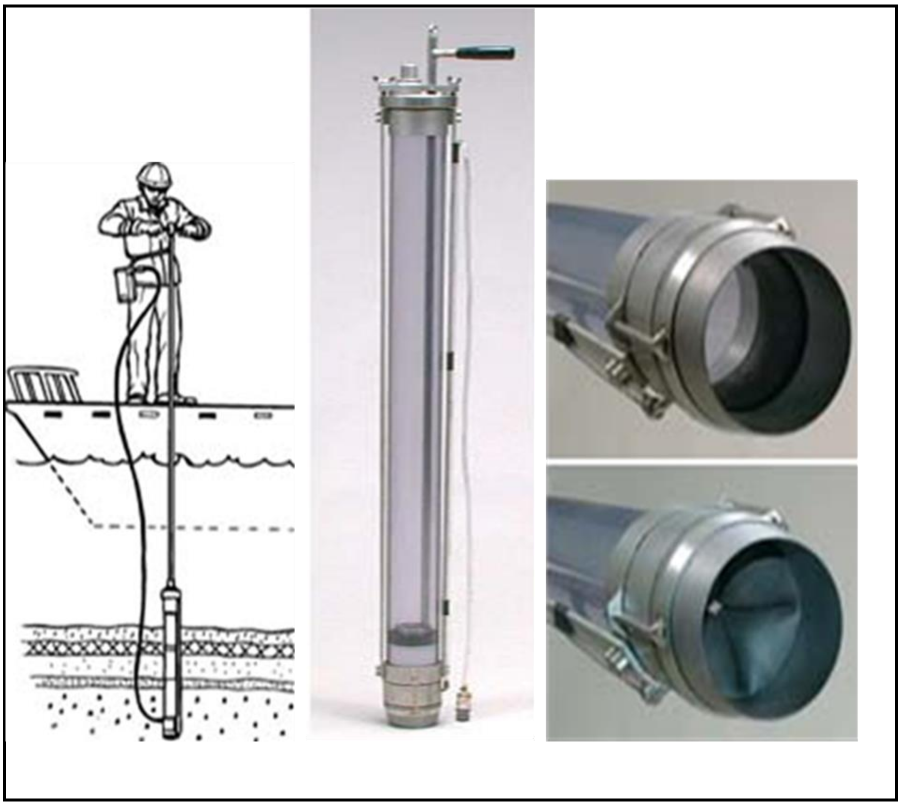

Fig. 2a. Measuring device for sediment samples extraction– the Beeker sampler.

Fig. 2b. Sediment sampling from boat at Chotárny channel in 2018.

The disturbed samples – determination of saturated hydraulic conductivity

Determination of saturated hydraulic conductivity from disturbed samples of bed silts can be calculated by empirical formulas coming out from grain size analysis (Kutílek, 1978; Kasenow, 2010). Several empirical formulas for determination of hydraulic conductivity from granularity exist, but it is possible to apply only a few of them because their limited validity. Therefore we used at first the relationships by Beyer-Schweiger and Špaček (Špaček, 1987) and later we added yet using of another four empirical formulas according to authors Hazen I., Bayer, USBR and Orechova (User's manual of software GeoFil). In all these mentioned relationships the value of saturated hydraulic conductivity K_d is function of d_{10}, d_{17}, d_{20} or d_{60} (particle diameters in 10%, 17%, 20% and 60% of soil mass). These parameters were determined from granularity curves of all extracted disturbed samples at Chotárny channel.

Beyer-Schweiger formula, used for determination of saturated hydraulic conductivity from disturbed samples K_{dBS} [m s^{-1}], is:

$$K_{dBS} = 7.5x10^6\, C\left(d_{10}\right)^2 \tag{1}$$

where C=1.5961x10^{-3} $(d_{60}/d_{10})^{-0.20371}$, d_{10} – particle diameter in 10% of soil mass [m], d_{60} – particle diameter in 60% of soil mass [m] and conditions of validity are:

$$0.06 \le d_{10} \le 0.6 \quad \text{and} \quad 1 \le \frac{d_{60}}{d_{10}} \le 20$$

Špaček formulas I., II. [m d^{-1}] for saturated hydraulic conductivity from disturbed samples K_d are:

$$K_{d\,ŠI.} = 20.577\left(d_{10}\right)^{1.013}\left(\frac{0.5}{d_{60} - d_{10}}\right)^{0.059} \tag{2}$$

$$K_{d\,ŠII.} = 108.4386\left(d_{10}\right)^{0.8866}\left(d_{60}\right)^{0.7726} \tag{3}$$

where conditions of validity for application of eq. (2) are:

$d_{10} < 0.01$mm

or

$0.01 \le d_{10} < 0.13 \;\wedge\; d_{60} < 0.0576 + 0.5765 d_{10}$

and conditions of validity for application of eq. (3) are:

$d_{10} \ge 0.13$mm

or

$0.01 \le d_{10} < 0.13 \;\wedge\; d_{60} > 0.0576 + 0.5765 d_{10}$

Hazen I. formula, used for determination of saturated hydraulic conductivity $K_{d\,H\,I.}$ [m s^{-1}], is:

$$K_{dHI.} = \frac{116(d_{10})^2}{100} \tag{4}$$

where d_{10} is particle diameter in 10% of soil mass [cm], the condition of validity is: $d_{15} < 0.6$ [cm].

Bayer formula $K_{d\,B}$ [m s^{-1}] is:

$$K_{dB} = U^b a(d_{10})^2 \tag{5}$$

$$U = \frac{d_{60}}{d_{10}}$$

where d_{10} is particle diameter in 10% of soil mass [cm]; d_{60} is particle diameter in 60% of soil mass (cm); a, b are constant factors – for consolidated soils a=0.01; b=-0.23; U is coefficient of uniformity; the conditions of validity are: 0.06 (cm) < d_{10} < 0.6 (cm) $\wedge$ U < 20.

USBR formula $K_{d\,USBR}$ [m s^{-1}] is:

$$K_{dUSBR} = \frac{0.36(d_{20})^{2.3}}{100} \tag{6}$$

where d_{20} is particle diameter in 20% of soil mass [mm]; the condition of validity is: 0.01 [mm] < d_{20} < 2.0 [mm].

Orechova formula $K_{d\,Or}$ [m s^{-1}] is:

$$K_{dOr} = \frac{640(d_{17})^2}{86400} \tag{7}$$

where d_{17} is particle diameter in 17% of soil mass [mm]; the condition of validity is: $g_{0,063}$ [mm] < 35%, it means that is valid for soils with fraction less than 0.063 mm content < 35 %.

The valid values of saturated hydraulic conductivity from disturbed samples of silts along the Chotárny channel K_d according to these 7 formulas were calculated and summarized in Table 1. The samples of silts were extracted in those selected cross-sections along the Chotárny channel where the larger thicknesses of silt were measured within that cross-section – in 8 locations (as the 1st column of Table 1 and Table 2 cites) – in km 1.2, 6.0, 8.6, 16.3, 18.0, 20.0, 24.6 and 25.5.

The undisturbed samples – determination of saturated hydraulic conductivity

In case of undisturbed samples of bed silts the values of saturated hydraulic conductivity were obtained by using of falling head method – direct measurement in laboratory. There was used the simplified equipment for measuring of saturated hydraulic conductivity from undisturbed samples – Fig. 3a (Šurda et al., 2013).

The formula for calculation of average value of saturated hydraulic conductivity K_u according to scheme on Fig. 3a is:

$$K_u = \frac{l}{\Delta h} \ln \frac{h2}{h1} \tag{8}$$

where K_u is the saturated hydraulic conductivity of undisturbed samples [cm.s^{-1}], l is a sample height [cm], h_1, h_2 – variable static head [cm] – see Fig. 3a.

The values of saturated hydraulic conductivity from undisturbed samples, extracted from 8 selected cross-sections at Chotárny channel (as was described above also in case of disturbed samples), were determined by the relationship (8) according to scheme on Fig. 3a. The results of values of saturated hydraulic conductivity from undisturbed samples K_u along the Chotárny channel are summarized in Table 2.

Table 1. Chotárny channel –values of K_d from disturbed samples of the bed silt layers in year 2018

Chotárny channel – 2018								
Channel stationing [km]	***Bed silt layer***	***K_d [m s^{-1}]***						
		Bayer-Schweiger	***Špaček I.***	***Špaček II.***	***Hazen I.***	***Bayer***	***USBR***	***Orechova***
1.2	top	3.81x10^{-08}	6.03x10^{-07}	(-)	6.14x10^{-08}	2.98x10^{-10}	(-)	(-)
	middle	(-)	(-)	1.02x10^{-06}	9.09x10^{-08}	(-)	(-)	(-)
	bottom	(-)	5.06x10^{-07}	(-)	4.64x10^{-08}	(-)	(-)	(-)
6.0	top	4.13x10^{-06}	(-)	2.62x10^{-05}	7.25x10^{-06}	3.20x10^{-08}	3.36x10^{-08}	2.24x10^{-07}
	middle	1.80x10^{-08}	4.23x10^{-07}	(-)	2.97x10^{-08}	1.40x10^{-10}	(-)	(-)
	bottom	6.30x10^{-05}	(-)	1.19x10^{-04}	9.40x10^{-05}	4.97x10^{-07}	5.84x10^{-07}	8.64x10^{-07}
8.6	top	(-)	7.64x10^{-07}	1.69x10^{-06}	1.19x10^{-07}	(-)	1.34x10^{-09}	(-)
	middle	(-)	(-)	2.04x10^{-05}	3.35x10^{-06}	(-)	1.84x10^{-08}	9.07x10^{-08}
	bottom	1.68x10^{-07}	1.24x10^{-06}	1.70x10^{-06}	2.90x10^{-07}	1.30x10^{-09}	1.15x10^{-09}	(-)
16.3	top	1.99x10^{-08}	4.45x10^{-07}	(-)	3.35x10^{-08}	1.54x10^{-10}	(-)	(-)
	middle	(-)	5.05x10^{-07}	(-)	4.64x10^{-08}	(-)	(-)	(-)
	bottom	3.32x10^{-08}	5.69x10^{-07}	(-)	5.61x10^{-08}	2.58x10^{-10}	(-)	(-)
18.0	top	2.15x10^{-08}	4.61x10^{-07}	(-)	3.55x10^{-08}	1.68x10^{-10}	(-)	(-)
	middle	(-)	4.11x10^{-07}	(-)	2.97x10^{-08}	(-)	(-)	(-)
	bottom	1.59x10^{-08}	3.99x10^{-07}	(-)	2.61x10^{-08}	1.24x10^{-10}	(-)	(-)
20.0	top	1.97x10^{-08}	4.44x10^{-07}	(-)	3.35x10^{-08}	1.53x10^{-10}	(-)	(-)
	middle	1.29x10^{-08}	3.66x10^{-07}	(-)	2.27x10^{-08}	1.00x10^{-10}	(-)	(-)
	bottom	1.37x10^{-08}	3.72x10^{-07}	(-)	2.27x10^{-08}	1.06x10^{-10}	(-)	(-)
24.6	top	(-)	5.50x10^{-07}	6.29x10^{-07}	5.61x10^{-08}	(-)	6.89x10^{-10}	(-)
	middle	(-)	1.66x10^{-06}	4.28x10^{-06}	5.68x10^{-07}	(-)	1.75x10^{-09}	1.90x10^{-08}
	bottom	(-)	5.16x10^{-07}	2.61x10^{-06}	6.14x10^{-08}	(-)	8.29x10^{-10}	(-)
25.5	top	1.06x10^{-07}	9.95x10^{-07}	1.27x10^{-06}	1.86x10^{-07}	8.15x10^{-10}	9.83x10^{-10}	(-)
	middle	(-)	6.60x10^{-07}	1.03x10^{-06}	8.46x10^{-08}	(-)	1.15x10^{-09}	(-)
	bottom	(-)	(-)	1.29x10^{-05}	1.23x10^{-06}	(-)	2.23x10^{-09}	2.27x10^{-08}

Symbol (-) means the conditions of validity for application of empirical formula are not maintained, e.g. the input values are located outside the range for this formula's application.

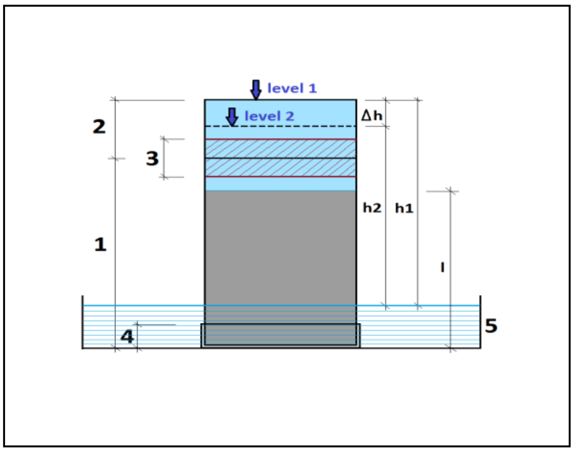

Fig. 3a. Simplified equipment for measuring saturated hydraulic conductivity of undisturbed sample: 1 – sampling tube height, 2 – Kopecky´s roller, 3 rubber ring, 4 – filter paper and wire strainer, 5 – Petri dish.

Fig. 3b. The demonstration of application of falling head method to 24 undisturbed samples from Chotárny channel.

Table 2. Chotárny channel – values of K_u from undisturbed samples of the bed silt layers in year 2018

Chotárny channel – 2018		
Channel stationing [km]	***Bed silt layer***	***K_u [m s^{-1}]***
	top	1.83x10^{-07}
1.2	middle	1.19x10^{-07}
	bottom	8.12x10^{-07}
	top	1.91x10^{-06}
6.0	middle	1.53x10^{-07}
	bottom	4.53x10^{-05}
	top	3.72 x10^{-07}
8.6	middle	1.62x10^{-06}
	bottom	3.20x10^{-07}
	top	2.50x10^{-06}
16.3	middle	3.01x10^{-07}
	bottom	3.18x10^{-07}
	top	9.69x10^{-07}
18.0	middle	1.07x10^{-06}
	bottom	7.68x10^{-08}
	top	7.62x10^{-07}
20.0	middle	1.01x10^{-07}
	bottom	8.08x10^{-08}
	top	5.82x10^{-06}
24.6	middle	2.57x10^{-06}
	bottom	1,51x10^{-06}
	top	1,00x10^{-06}
25.5	middle	2.76x10^{-07}
	bottom	7.25x10^{-06}

The results at every single cross-section are quite various – km 1.2 is pretty consistent 10^{-07}, km 6.0 shows huge differences from 10^{-05} to 10^{-07}, km 8.6 is somewhat consistent from 10^{-07} to 10^{-06}, km 16.3 is also somewhat consistent from 10^{-06} to 10^{-07}, km18.0 shows huge differences from 10^{-06} to 10^{-08}, km 20.0 and km 25.5 are also somewhat consistent and km 24.6 is also pretty consistent 10^{-06}. We can conclude that in single layers of silt at single cross-sections the differences between top, middle and bottom layer there were not any in two cross-sections (km 1.2 and 24.6), in four cross-sections the differences between top, middle and bottom layer were on order of tenfold (km 8.6, 16.3, 20.0 and 25.5) and in two cross-sections these differences were on the order of a hundredfold (km 6.0 and 18.0). We could try to clarify the cause of these differences in another paper in the future.

In case of comparison of the values of K_u in its single layers - between top, middle and bottom layer within one cross-section – there was no significant impact of the level and the results were scattered throughout the cross section, except in two cases – the cross-section in km 6.0 and in km 18.0.

Results and discussion

As was mentioned before there were used two ways for determination of saturated hydraulic conductivity values of bed silts at the Chotárny channel. The results obtained from both were compared in this study. The values of saturated hydraulic conductivity were in both cases determined for the top, middle and bottom layer of extracted bed silt samples.

The value of saturated hydraulic conductivity, as the indicator of bed silt permeability, was calculated at first for disturbed samples of bed silts – by seven empirical formulas. Each of them determines this variable quantity as a function of d_{10}, d_{17}, d_{20} and d_{60} (particle diameter in 10, 17, 20 and 60% of soil mass). Conditions of validity for application of these seven formulas also depend on value of d_{10}, d_{17}, d_{20} and d_{60}. The values of saturated hydraulic conductivity of disturbed samples K_d, computed from 7 empirical formulas, are summed in Table 1. The valid values of saturated hydraulic conductivity of bed silt from single layers reached from 1.00x10^{-10} to 1.19x10^{-04} m s^{-1}, depending on the formula. The range of these results is in the order of thousand. This enormous difference could be caused by influence of the bed silt grain size which is determined from the grain size curve. Perhaps also other phenomenon, such as thickness of layer, temperature, etc. could be responsible for this difference.

In comparison with saturated hydraulic conductivity values of surrounding aquifer near the Chotárny channel the values of bed silts are severalfold lower.

For comparison of results mentioned in Table 1 we used the count of valid results, computed from each empirical formula according seven authors, as a criterion for recommending relevant formula for computation of bed silt values of saturated hydraulic conductivity K_d. The recommended formula for calculation of K_d based on this criterium for Chotárny channel is Hazen I. formula – from 24 extracted disturbed samples we obtained 24 valid values of saturated hydraulic conductivity. Fig. 4 represents the statistical presentation of number of K_d.

The other method of determination of the values of saturated hydraulic conductivity for undisturbed samples was falling head method. The results obtained by this way are summed in Table 2. The valid values of channel bed silt saturated hydraulic conductivity from undisturbed samples K_u reached from 7.68x10^{-08} to 4.53x10^{-05} m s^{-1}.

We made the comparison of the values of saturated hydraulic conductivity obtained from disturbed and undisturbed samples of bed silts at Chotárny channel in 2018.

In case of disturbed samples the values of saturated hydraulic conductivity K_d run into 10^{-10} to 10^{-05}, whereby the values 10^{-08} predominated (Table 1). In case of undisturbed samples the values of saturated hydraulic conductivity K_u run into 10^{-08} to 10^{-05}, predominant values were 10^{-07} (Table 2).

At comparison of single layers of bed silts, extracted as disturbed samples, we found out that between top, middle and bottom layers were almost none differences or in a few cases only ten to hundred fold.

In case of comparison of undisturbed silt samples in its single layers the differences between top, middle and bottom layer were tenfold up-to hundredfold.

At last it was made comparison of values of saturated hydraulic conductivity from disturbed samples according Hazen I. (selected by criterion of the largest number of obtained results) and from undisturbed samples. From this comparison arised the interesting outcome which showed that in case of disturbed samples the values of saturated hydraulic conductivity according Hazen I. 10^{-08} predominate and these values are tenfold-to hundredfold less than the values from undisturbed samples. Fig. 5a represents the illustration of saturated hydraulic conductivity values from disturbed samples, for comparison at Fig. 5b are saturated hydraulic conductivity values from undisturbed samples at Chotárny channel in 2018.

The scales of both graphs are different due to the big differences in the values of saturated hydraulic conductivity. Further study in the future will be conducted to investigate the reasons why the values differ vastly.

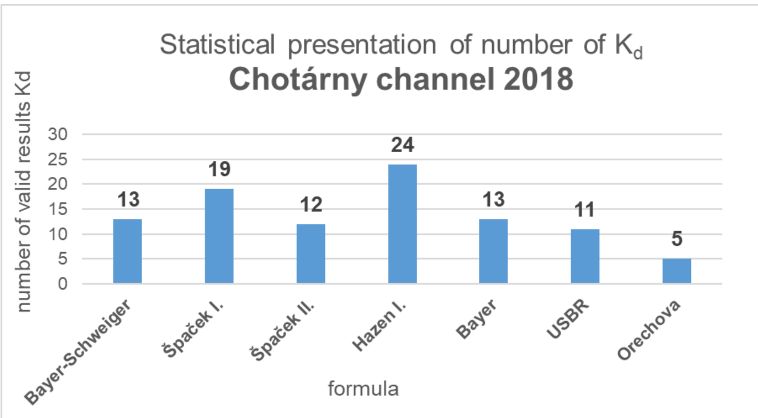

Fig. 4. The illustration of statistical evaluation of data range.

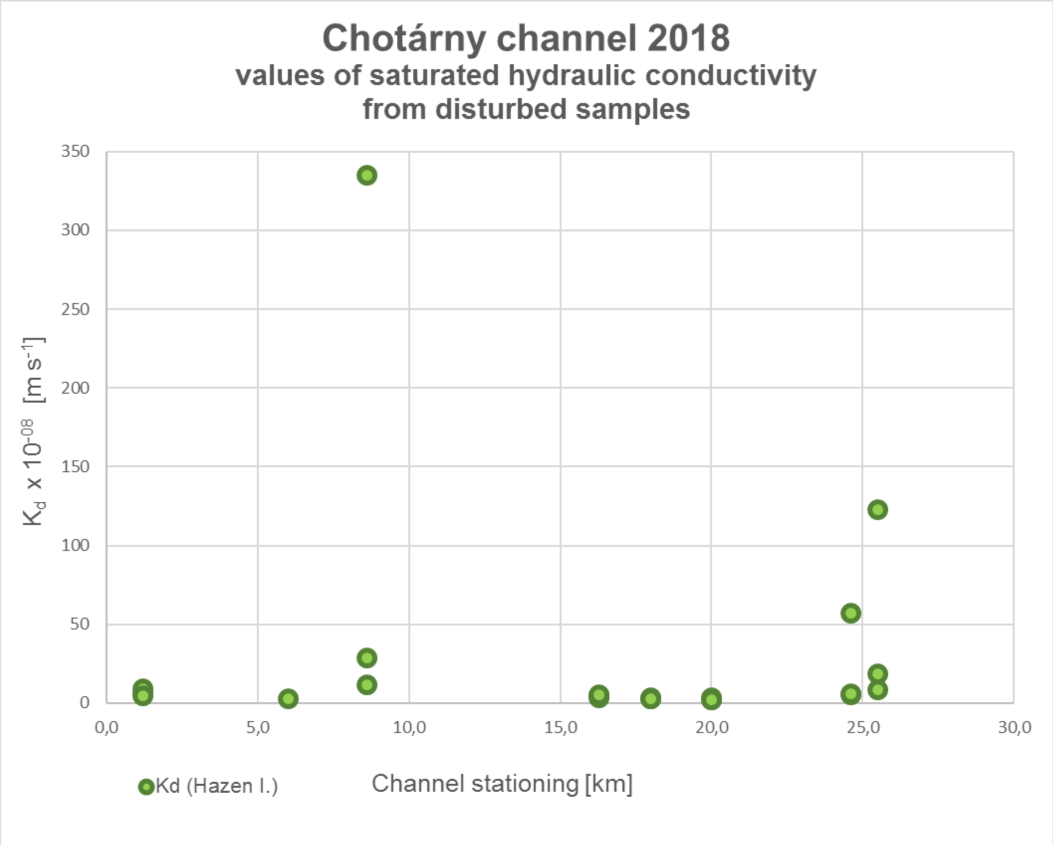

Fig. 5a. The illustration of saturated hydraulic conductivity values from disturbed samples at Chotárny channel in 2018.

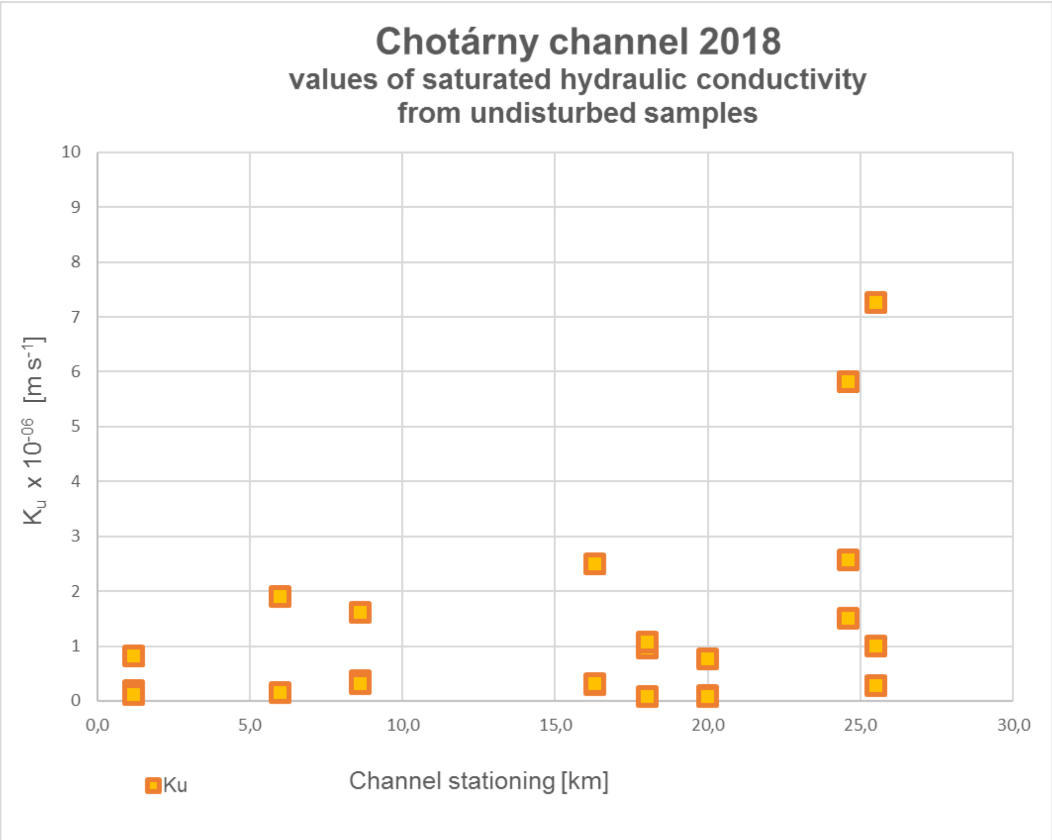

Fig. 5b. The illustration of saturated hydraulic conductivity values from undisturbed samples at Chotárny channel in 2018.

Conclusion

This study directs at the determination of bed silt permeability along the Chotárny channel on base of field measurements performed during 2018 and comparison of two ways for determination of its saturated hydraulic conductivity. The thickness of bed silts and its permeability fundamentally influence and determine the rate of mutual interaction between surface water in the Chotárny channel and groundwater in its surroundings. For this reason, it is important to research and monitor continuously the state of channel bed aggradation and to know the permeability of bed silts, expressed by its value of saturated hydraulic conductivity.

The values of saturated hydraulic conductivity of bed silts along the Chotárny channel were determined by two ways. The first way was by using of calculation according to seven empirical formulas applicable for disturbed samples of bed silts based on granularity analysis of disturbed samples. The resultant values are presented in Table 1. The valid values of saturated hydraulic conductivity for single parts of bed sediment layers reached from $1.00x10^{-10}$ to $1.19x10^{-04}$ m s^{-1}.

The second way was using of falling head method by direct measurement in laboratory applicable for undisturbed samples of bed silts. The resultant values are presented in Table 2. These values of saturated hydraulic conductivity for single parts of bed silt layers reached from $7.68x10^{-08}$ to $4.53x10^{-05}$ m s^{-1}.

The comparison of the values of saturated hydraulic conductivity obtained from disturbed and undisturbed samples of bed silts at Chotárny channel in 2018 was made. The comparison of these results concluded that the values differ to a great extent.

In case of comparison of undisturbed silt samples in its single layers the differences between top, middle and bottom layer were tenfold up-to hundredfold.

From the comparison of values of saturated hydraulic conductivity from disturbed samples according Hazen I. and undisturbed samples was that in case of disturbed samples the values of saturated hydraulic conductivity according Hazen I.

All obtained information about bed silt thicknesses supplemented by values of saturated hydraulic conductivity of bed silt can be eligible for numerical simulation models and simultaneously they represent valuable information for any future way of groundwater level regulation in surroundings of the Chotárny channel and other channels at the ŽO area.

Acknowledgement

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