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EFFECTS OF NATURAL CUT-OFF MEANDERS AND REVITALIZATION CHANNELS ON THE MOISTURE REGIME OF A FLOODPLAIN FOREST

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Abstract

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Areas created by the alluvial sediments of the Morava and Dyje rivers are of a specific microrelief interwoven sporadically by the rich network of natural cut-off meanders (so called "smuhy") or artificial channels developed in the past or at present. Under original natural conditions of a nearly regularly flooded alluvial plain they served for the faster runoff of inundation waters to the river channels. After water-management measures carried out in the 70s of the 20th century, much of the cut-off meanders, silted cut-off lakes and artificial channels lost water totally or during part of the year. Thus, only a revitalization system established at the beginning of the 90s brought their re-filling. Problems of a new "irrigation" function of the revitalization system were studied in the complex of the Kančí obora floodplain forest at Forest District Valtice, Forest Enterprise Židlochovice. In principle, it refers to inter-relationships and effects of the groundwater level dynamics depending on the flow of water in water bodies and water freely running through channels. Hydrogeological conditions of Quaternary sediments in alluvia of rivers with virtually regular annual dynamics of the groundwater level are of fundamental importance. Permeability conditions of soil profiles of largely heavy-textured Fluvisols with relatively favourable physical conditions are also important. The different hydraulic conductivity of the bed and slopes of channels are of fundamental role at assessing the function of a revitalisation system.

Key words: floodplain forest, soil moisture dynamics, groundwater, revitalisation channels, hydraulic conductivity

Introduction

Floodplain forests of the Czech Republic are small as for their total area. However, with respect to their importance for biodiversity and ecological stability of wide alluvial plains of rivers and also for this type of a landscape element they are irreplaceable (Klimo et al., 2008; Heteša, 2002; Štěrba, 1994). One of the largest complexes of floodplain forests in the Czech Republic is situated above the confluence of the Morava and Dyje rivers. This area is intensively used by man for its rich supply of natural resources already since a historical era (Décamps et al., 1988; Klimek, 1987; Poláček, 2004). One of the most valuable resources is also water. Thus, not only the existence of man but mainly of floodplain forest is dependent on it. The floodplain forest has been adapted to the natural balance at spring surplus (originally annual inundations) and autumn minimum from time out of mind. Water-management measures carried out on the Dyje and Morava rivers changed to a great extent the moisture regime of soils and the water balance for floodplain ecosystems (Čermák, Prax, 2002). In the 90s of the 20th century, foresters at the Židlochovice Forest Enterprise tried to deal with the moisture deficit through the realization of revitalization projects (Vybíral, 2002). One of the most important problems dealt with in this paper is to elucidate the importance and real functions of revitalisation channels to optimise the moisture regime of soils.

Material and methods

Problems of the function of the network of revitalisation channels, cut-off meanders and silted cut-off lakes situated in the youngest Holocene layer of heavy-textured sediments were studied in the right-bank flood plain of the Dyje river. It refers to a “model area” of the floodplain forest complex called “Kančí obora”, Forest District Valtice, Forest Enterprise Židlochovice. Forest revitalization measures were carried out there in the period 1991–1996. Their intention was to optimize the moisture regime of soils after an unfavourable response, i.e. decreasing the dynamics of the groundwater level after water-management measures at the Dyje river channelization in the 70s of the 20th century (Kloupar, 2002). Apparent drying was documented of mature stands, namely not only of soft-wooded but also of hard-wooded broadleaves of the floodplain forest. Data were evaluated obtained by workers of the Institute of Forest Ecology (IFE) since the end of the 60s of the 20th century at research into floodplain forest ecosystems (Penka et al., 1985, 1991) and also data, which were available from measuring stations of the Czech Hydrometeorological Institute (CHMI) in Brno in the Dyje and Morava floodplains monitored for a long time.

The actual function of revitalisation channels was monitored at specially established trials (localities A, B and C) (Figs. 1a, b) at the artificially induced filling and discharge of monitored channels, which was made possible under certain conditions by the established revitalization system. Permeability conditions of the channel bed and slopes were determined on intact soil samples evaluated in the hydropedological laboratory of the ČVUT (Czech University of Technology) in Prague.

Locality A situated in a research area of the IFE near Lednice na Moravě represents a typical revitalisation channel with slopes 1:1.5 and bed 2.0 m in width where, in the upper third of the slope, 10 Kopecký’s physical cylinders were sampled and the same number was sampled from the channel bed. The bed was virtually free of water in the period of sampling. The same procedure was carried out at Locality B (Varadínek) in the Kančí obora wetland, which represents the type of a wide cut-off meander (12 m in width) with gradual slopes and a flat bed. On slopes and on the bed, always 8 undisturbed samples were taken. On the bed of the cut-off meander, about 10 cm water occurred and samples were taken below the water level. Sampling had to be carried out in the period of the low groundwater level (in a neighbouring stand) situated generally below the channel bed level. Such situation occurs at minimum discharges in the Dyje river, which is the primary source of groundwater in the floodplain forest.

The movement of the groundwater level infiltrating from the channel walls was monitored at transects of soil boreholes situated in certain distances perpendicular to the channel axis. At Locality B (Varadínek), there were 7 soil boreholes of a diameter of 6 cm and depth 200 cm. The boreholes were strengthened by plastic perforated tubes. Borehole 1 was situated 1 m from the cut-off meander edge, borehole 2 – 6 m, borehole 3 – 11 m, borehole 4 – 21 m, borehole 5 – 31 m, borehole 6 – 41 m and borehole 7 – 51 m from the cut-off meander. The boreholes were realized on 10th October 2008.

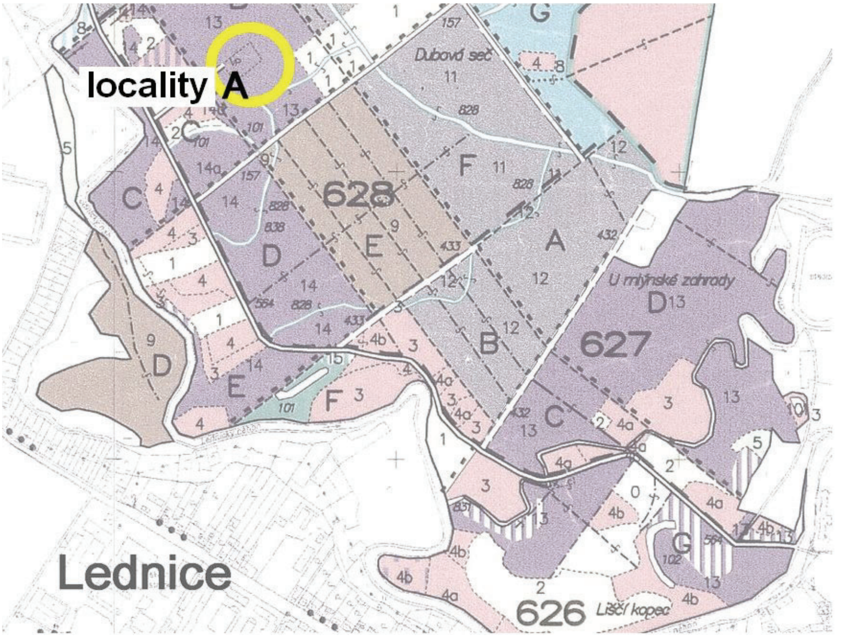

Fig. 1a. Locality A.

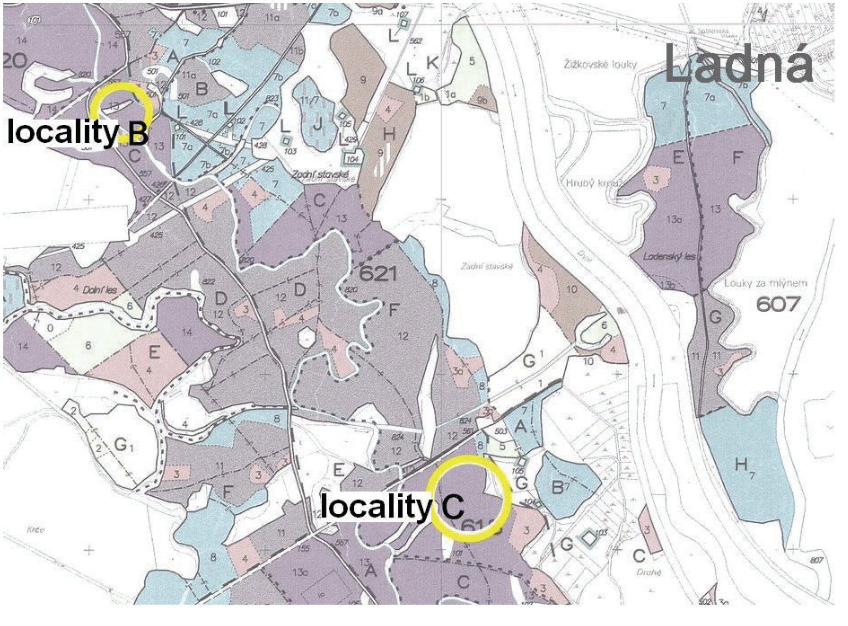

Fig. 1b. Localities B, C.

At Locality C (Ladenská alej alley), there were 4 boreholes up to a depth of 200 cm, which were equipped similarly as at Locality B. Borehole 1 was situated 1 m from the channel edge, borehole 2 – 2 m, borehole 3 – 5 m and borehole 4 – 51 m from the channel edge. The revitalization channel is 1.7 m deep, 6 m wide and the slope of its walls is 1:1.

Results and discussion

The moisture regime of soils of the floodplain forest is permanently monitored at the research area locality of the Institute of Forest Ecology, Mendel University in Brno since 1969. In the period of the area establishment, regular spring or also summer short-term floods occurred at the overflow of water from the Dyje river. After completing the Dyje river channelization in 1972, the moisture regime of soils substantially changed, namely by the elimination of floods in the floodplain forest and also by a certain fall of the groundwater level preserving the important annual dynamics of spring maxima and autumn minima as documented in Fig. 2 including chronoisopleths.

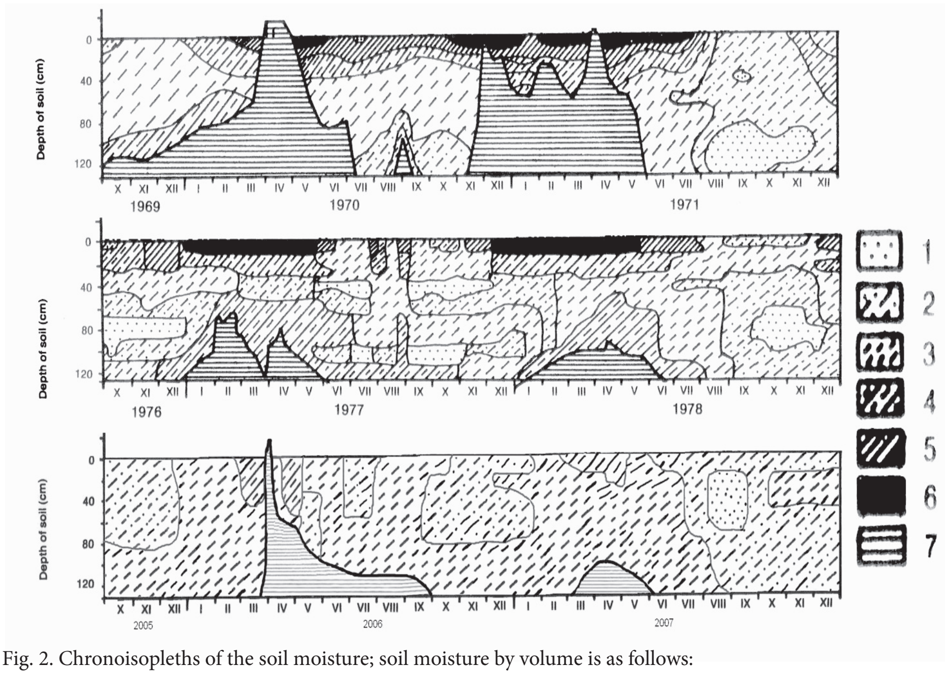

Fig. 2. Chronoisopleths of the soil moisture; soil moisture by volume is as follows:
1: 25–30%, 2: 30–35%, 3: 35–40%, 4: 40–45%, 5: 45–50%, 6: 50–55%, 7: groundwater).

The year 2006 was an exception. After 34 years at the end of March, a short-term flood occurred caused by the sudden and intense thawing of high supplies of snow (Palát et al., 2010) lying at higher locations of the Dyje river drainage area (Fig. 3).

At the end of the 80s after the period of precipitation-subnormal years, the floodplain forests were sporadically affected by moisture stress, which was detectable by drying up the older stands of soft-wooded as well as hard-wooded broadleaves. Workers of Forest Enterprise Židlochovice responded to the situation by the realization of revitalisation projects at particular forest districts at the beginning of the 90s of the 20th century.

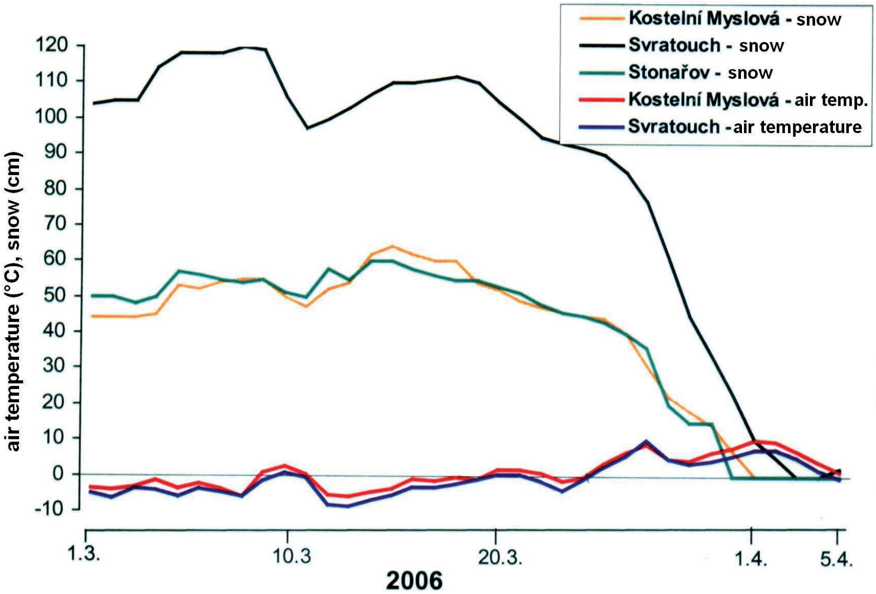

Fig. 3. The course of values of the snow depth at localities Kostelní Myslová (Dyje), Stonařov (Jihlava) and Svratouch (Svratka river) at the turn of March and April 2006.

The moisture regime of soils plays an important role both in the biomass production and in the biodiversity of floodplain ecosystems (Hadaš, 2003). An example of the woody biomass production is documented by the radial increment study (Prax P. et al., 2002) carried out at the group of 20 trees of ash (*Fraxinus angustifolia*) in a mature stand in Forest District Tvrdonice (Fig. 4).

The groundwater level saturating at its dynamics the surface layer of heavy-textured sediments at least in spring months is an inevitable condition of the sustainable existence of floodplain ecosystems in southern Moravia. In the precipitation-deficit area of southern Moravia, local atmospheric precipitation cannot cover evapotranspiration requirements of vegetation. A water-withdrawal area of the Holič group water main, where the groundwater level fell in some places by more than 5 m (Fig. 5), can serve as an example of the critical water balance at a locality with the marked decline of groundwater towards underlying gravel sand (Hadaš, Prax, 2001).

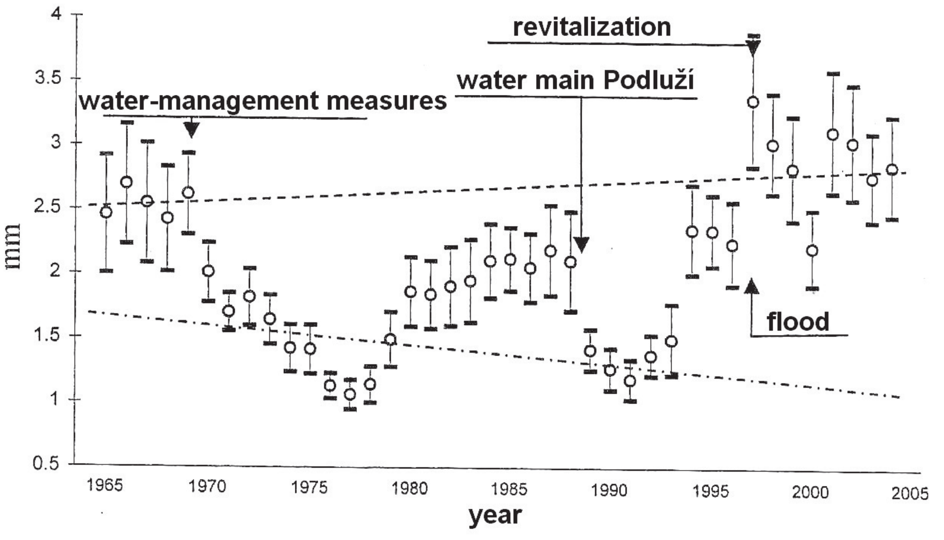

Fig. 4. The course of the radial increment of ash in particular years.

The three-year monitoring (1981–1983) demonstrates that after the winter saturation of the soil profile, its total drying occurs early up to the value of a wilting point. Parallel conditions at the Moravská Nová Ves locality under unaffected groundwater level show favourable water balance where soil moisture ranges mostly between soil-moisture constants of the decreased availability point and field moisture capacity.

The groundwater level availability and its inevitable fluctuation in the course of the year ensure not only the sufficient supply of water to the root system of trees but also enough soil air, i.e. favourable oxidation-reduction environment. Every intervention of man into conditions given by nature means changes in conditions for the growth of vegetation.

Water-management measures in the 70s of the 20th century resulted in the marked impact of the soil moisture regime of the floodplain forest where the floodplain forest water supply was decreased at least by spring inundations. Foresters looked for improvement (remedy) in processes of flooding or waterlogging if it was enabled by some parts of the floodplain. Revitalization systems realized in the 90s of the 20th century appear to be a more complex solution. By means of these measures water was led to restored or newly established channels, cut-off meanders or pools, which were free of water for most of the year after water-management measures. Through field experiments, effects of revitalization systems were monitored on the possibility to supply water to the surroundings of channels and on the movement of the groundwater level along these channels.

In the first place, physical conditions and permeability of the channel bed and slopes were determined at two localities. Results of the examination of soil samples are given in Tables 1 and 2 (locality A – the IFE research area at Horní les) and Tables 3 and 4 (locality B – Varadínek in the Kančí obora wetland).

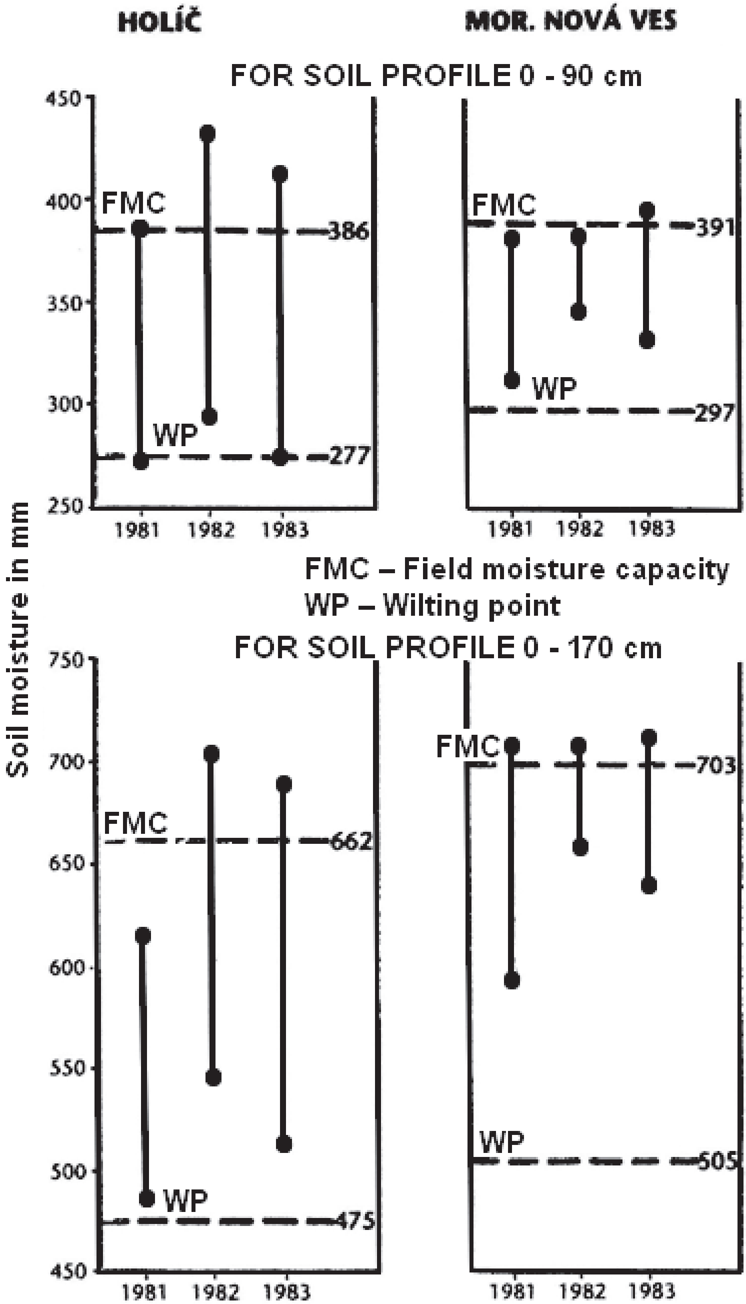

Fig. 5. Soil moisture at the Holíč water main area.

Skeletonless and rather uniform loamy soils from slopes with mildly acid active+ acid exchangeable soil reaction are humus, structural and permeable. Clay-loam soils from the channel bed with the very high content of C_{ox} are also mildly acid to acid. In the skeletonless fine-grained matrix, there are undecomposed or only partly decomposed remnants of plants.

T a b l e 1. Assessing soil samples from Locality B – Varadínek.

Profile 1 – channel slope – the set of 8 undisturbed samples
Profile 2 – channel bed – the set of 8 undisturbed samples (sampling about 10 cm under water)
Varadínek – selected soil characteristics. Sampling 25/4 2009.

Set No.	Sample	Clay	Silt	Sand	C_{ox}	Humus	Soil textural classes
		%	%	%	%	%	
1	15	14	64	22	2.78	4.79	loamy
slope	25	11	60	29	2.73	4.71	loamy
	27	12	62	26	2.67	4.61	loamy
	28	15	63	22	3.39	5.84	loamy
	77	13	68	19	2.92	5.03	loamy
	85	16	65	19	2.76	4.76	loamy
	238	14	65	21	2.89	4.98	loamy
	249	15	64	21	3.75	6.46	loamy
2	17	18	66	16	6.37	10.98	clay-loam
bed	66	18	65	17	5.17	8.91	clay-loam
	67	19	66	15	5.97	10.29	clay-loam
	76	19	64	17	5.77	9.94	clay-loam
	147	18	66	16	6.60	11.38	clay-loam
	153	16	63	21	5.08	8.75	clay-loam
	154	17	64	19	5.00	8.62	clay-loam
	167	12	63	25	6.64	11.45	loamy

Notes: clay d < 0.002 mm; silt d = 0.002-0.063 mm; sand d = 0.063-2.0 mm
skeleton d > 2 mm in all 18 samples < 1%
C_{ox} (determined by oxidimetry) $_*$1.724 = humus – very high content
pH_{H2O} = 5.56–6.16 (weak acid active reaction of a soil suspension)
pH_{KCl} = 5.12–5.62 (weak acid to acid exchange reaction of a soil suspension)
Determination of soil texture for geotechnics, the ČSN 721017 Standard Texture class was determined according to Novák's classification (classification according to the proportion of particles d < 0.01 mm).

Samples taken under the water level in the channel show (after desiccation) considerable volume changes and, therefore, they are of low volume weight (density). In the fully saturated porous system with the predominance of fine semicapillary to capillary pores, transfer phenomena are evident of iron compounds in the anaerobic environment.

Laboratory determination of the filtration coefficient was carried out according to the ČSN 72 1020 Standard (suitably adapted method F) at the set of 2×8 undisturbed fully saturated samples, which were gradually subject to a various constant and variable energy gradient

T a b l e 2. Hydrophysical characteristics of locality B – Varadínek.

Sample	θ_{mom}	θ_{sat}	MKK_{2h}	HP	SP	KP	P	ρ_d	K_s
No.	% vol.	%	% vol.	%	%	%	%	$kg.m^{-3}$	$m.s^{-1}$
15 - 1	39.4	60.3	50.1	6.4	7.1	46.9	60.4	1036.7	$9.5.10^{-6}$
25 - 1	45.7	62.4	52.6	6.2	7.5	48.9	62.6	975.8	$3.7.10^{-5}$
27 - 1	39.9	57.1	46.7	5.9	8.6	43.3	57.8	1112.9	$6.2.10^{-5}$
28 - 1	40.8	60.9	49.8	6.8	9.8	47.0	63.6	911.4	$7.8.10^{-5}$
77 - 1	40.7	58.7	45.3	10.4	9.3	41.9	61.6	959.2	$9.7.10^{-5}$
85 - 1	44.0	61.3	52.9	6.9	6.2	48.7	61.8	955.1	$9.6.10^{-5}$
238 - 1	43.7	63.3	55.4	5.6	6.1	51.6	63.3	958.9	$1.3.10^{-5}$
249 - 1	36.6	62.3	49.1	8.8	8.9	45.1	62.8	908.8	$6.6.10^{-5}$
17 - 2	78.8	78.9	76.2	1.6	7.5	69.8	75.1	657.9	$2.7.10^{-7}$
66 - 2	74.2	74.3	73.0	0.5	4.2	68.6	69.9	775.1	$1.0.10^{-8}$
67 - 2	73.6	73.6	71.7	1.2	4.5	67.9	73.4	640.7	$1.8.10^{-8}$
76 - 2	75.2	75.2	73.5	0.8	5.5	68.9	69.8	785.9	$4.1.10^{-8}$
147 - 2	80.5	80.5	78.7	3.1	8.7	68.7	76.4	590.8	$2.3.10^{-6}$
153 - 2	78.9	79.0	76.5	2.0	7.8	69.2	73.8	654.4	$1.7.10^{-7}$
154 - 2	74.7	74.8	72.7	1.1	6.9	66.8	73.6	660.6	$9.5.10^{-7}$
167 - 2	75.7	75.8	74.7	0.1	6.8	68.9	71.8	745.2	$1.5.10^{-8}$

Notes: MKK – maximum capillary moisture capacity characterizes the possibility of soil to retain water for needs of vegetation. It is used as a value of the soil water capacity (field capacity PK = FC).
ρ_d – volume weight, θ_{mom} – actual moisture, HP – coarse pores, SP – semicapillary pores, KP – retention water capacity (corresponds roughly to the volume of capillary pores), $\rho\rho_s$ – specific density of soil (apparent density of solid particles) = 2.41–2.65 $g.cm^{-3}$, $\theta_{sat.}$ – maximum moisture (fully saturated pore system), P – porosity, Ks – coefficient of hydraulic saturated conductivity (filtration coefficient).

(virtual slope). Resulting measured values $K = n.10^{-7}\text{-}10^{-8}\ m.s^{-1}$ define bed clay-loam soils of low volume weight and the absolute predominance of capillary pores as limitedly permeable to impermeable. Loamy soils from the slope are permeable because they have more preference roads and non-capillary pores in the pore systems ($K= n.10^{-5}\ m.s^{-1}$).

Soil class was determined according to Novák's classification (classification according to the proportion of particles d < 0.01 mm)

Determination of soil texture for geotechnics (particle-size lines are part of the paper) was caried out according to the ČSN 721017 Standard.

T a b l e 3. Assessing soil samples from the locality A – Lednice.

Lednice - SELECTED soil characteristics

Set	Sample	Clay	Silt	Sand	Skeleton	D_{50}	C_{ox}	pH active and exchangeable		Soil textural classes
No.		%	%	%	%	mm	%	pH_{H2O}	pH_{KCl}	
1	17	16	52	32	26	0.017	0.94	4.61	3.92	loamy
slope	27	16	49	35	13	0.019	0.89	5.02	4.11	loamy

T a b l e 3. (Continued)

Set	Sample	Clay	Silt	Sand	Skeleton	D_{50}	C_{ox}	pH active and exchangeable		Soil textural classes
	66	18	41	41	33	0.021	1.58	4.61	4.37	loamy
2	15	18	66	16	13	0.009	1.67	5.67	5.48	clay-loam
bed	167	18	59	23	15	0.011	1.29	5.73	5.39	clay-loam
3	25	15	55	30	8	0.018	1.89	5.01	4.49	loamy
slope	85	18	52	30	6	0.016	1.92	5.49	5.26	loamy
	153	16	53	31	25	0.017	1.86	5.38	5.04	loamy
4	154	20	60	20	4	0.009	1.31	5.56	5.27	clay-loam
bed	243	20	61	19	2	0.010	1.58	5.54	5.22	clay-loam

Notes: 1 – set of undisturbed samples on the channel slope, 2 – set of undisturbed samples in the channel bed, 3 – set of undisturbed samples on the channel slope, 4 – set of undisturbed samples in the channel bed
clay d < 0.002 mm; silt d = 0.002–0.06 mm; sand d = 0.06-2.0 mm
skeleton d > 2 mm; C_{ox} (determined by oxidimetry) $_*$1.724 = humus.

Loamy soils from Slope 1 are of skeleton-type, with the low to medium content of organic substances and acid active + heavy acid exchangeable soil reaction.

Loamy soils from Slope 3 are of the high content of oxidizable carbon (3% humus) and acid active and exchangeable reaction.

Clay-loam soils from the bed with the medium content of C_{ox} are rather uniform, with slightly acid active and acid exchangeable soil reaction. In the fine-grained soil proportion, various plant parts are included (acorns, twigs, leaves) and the variable proportion of gravel rounded due to transport. In the fully saturated capillary porous system of bed sediments, there is an evident horizontal and vertical transport of Fe compounds.

Laboratory determination of the filtration coefficient was carried out according to the ČSN 72 1020 Standard (suitably adapted method F) using the set of 20 undisturbed fully saturated samples, which were gradually subject to the various constant and variable energy gradient. Resulting measured values $K = n.10^{-6}$-10^{-9} $m.s^{-1}$ define bed clay-loam soils of low volume weight and the absolute predominance of capillary pores as limitedly permeable to impermeable. Loamy soils coming from slopes with the higher proportion of sand show in the porous system more non-capillary pores and, therefore, they behave as slightly permeable to permeable ($K = n.10^{-5}$-10^{-7} $m.s^{-1}$)

In both cases, there is an evident difference in the particle-size distribution of soils when the channel bed shows the higher proportion of clay and less sand grains as against higher

Ta b l e 4. Hydrophysical characteristics of the locality A – Lednice.

Sample	θ_{mom}	θ_{sat}	MKK_{2h}	HP	SP	KP	P	ρ_d	K_s
No.	% vol.	%	% vol.	%	%	%	%	$kg.m^{-3}$	$m.s^{-1}$
17 - 1	35.9	46.7	41.1	5.0	3.4	38.3	46.7	1356.1	$3.5.10^{-5}$
27 - 1	35.2	41.6	39.5	1.6	1.8	38.2	43.4	1448.2	$3.8.10^{-7}$
66 - 1	28.9	42.6	36.3	5.2	3.3	34.1	42.5	1471.0	$1.0.10^{-5}$

Ta b l e 4. (Continued)

Sample	θ_{mom}	θ_{sat}	MKK_{2h}	HP	SP	KP	P	ρ_d	K_s
77 - 1	34.1	41.5	38.3	2.1	2.4	37.0	42.5	1467.1	$5.7.10^{-6}$
250 - 1	30.3	47.2	40.7	5.3	3.1	38.8	47.2	1344.6	$1.3.10^{-5}$
15 - 2	62.9	63.0	60.9	1.1	2.2	59.7	62.9	964.3	$7.5.10^{-9}$
67 - 2	61.6	62.2	58.8	2.5	4.1	55.6	61.0	1036.4	$3.6.10^{-6}$
167 - 2	58.9	59.9	57.8	1.4	3.4	55.1	59.9	1052.3	$1.1.10^{-7}$
234 - 2	55.9	57.5	53.2	1.3	3.3	52.9	57.4	1085.2	$3.2.10^{-8}$
238 - 2	65.4	66.5	62.2	1.5	2.8	62.2	65.2	982.6	$7.4.10^{-7}$
25 - 3	34.9	55.2	48.2	3.6	3.8	44.8	52.2	1222.7	$2.7.10^{-6}$
76 - 3	33.5	53.4	46.5	4.3	5.5	43.6	53.3	1176.6	$4.3.10^{-6}$
85 - 3	31.1	47.8	43.7	3.7	3.0	41.1	47.7	1340.4	$6.4.10^{-7}$
147 - 3	36.3	49.2	44.5	3.0	2.8	43.4	49.1	1303.0	$4.8.10^{-7}$
153 - 3	33.4	44.6	39.4	4.4	2.2	38.0	44.6	1414.9	$1.9.10^{-6}$
28 - 4	59.7	61.3	58.8	1.9	2.5	56.9	59.7	1070.9	$1.9.10^{-7}$
96 - 4	61.2	62.8	60.6	1.5	2.3	59.0	61.1	1031.5	$1.7.10^{-8}$
154 - 4	62.7	63.6	61.2	1.7	2.6	59.3	63.5	966.9	$1.1.10^{-7}$
243 - 4	57.9	58.9	56.8	0.8	1.0	57.3	58.0	1119.2	$5.8.10^{-9}$
249 - 4	58.0	58.9	57.1.	1.0	1.6	56.3	57.2	1141.8	$7.2.10^{-9}$

Notes: MKK – maximum capillary moisture capacity characterizes the possibility of soil to retain water for needs of vegetation. It is used as a value of the soil water capacity (field capacity PK = FC).
ρ_d – volume weight, θ_{mom} – actual moisture, HP – coarse pores, SP – semicapillary pores, KP – retention water capacity (corresponds roughly to the volume of capillary pores), $\rho\rho_s$ – specific density of soil (apparent density of solid particles) = 2.55–2.66 g.cm^{-3},$\theta_{sat.}$ – maximum moisture (fully saturated pore system), P – porosity, Ks – coefficient of hydraulic saturated conductivity (filtration coefficient).

locations on the channel slopes. Also values of organic substances (C_{ox}) are roughly double as compared to data on the slope. The particle-size distribution also markedly affected physical parameters where there are the majority of fine capillary pores, which increases the general soil porosity but partly limits the permeability of soil for water. Favourable values are also demonstrated by other physical quantities such as maximum capillary capacity and the retention capacity of soils. Parameters mentioned above significantly affect the coefficient of hydraulic conductivity, namely by two or even three orders from a value of x.10^{-5} m.s^{-1} on the channel slope up to x.10^{-8} m.s^{-1} at the channel bed.

In the second half of 2009, three field measurements were carried out aimed at the effect of water in the channel on the groundwater level in its near surroundings. At locality A, the prepared experiment could not be completed with respect to the insufficient water inflow to the transect place with observation boreholes. A reason consists in the considerable length of the channel (2 km) and partly silted filling (take-out) facility.

At locality B, the experiment was carried out in the period 27 October to 9 November (Fig. 6). Based on the graphical illustration it is evident that increasing the water level in the channel by about 30 cm became immediately evident at Borehole 1 at a distance of 1.0 m from the channel edge. Also in other boreholes, the groundwater level gradually increased. The experiment was terminated on 30 October. The fall of water was also gradually monitored in the channel and boreholes until 9 Novovember. On a day of finishing the channel filling on 30 October, it was evident that virtually in all 7 boreholes, the groundwater level increased nearly by the same height as the increased water level in the channel, i.e. by about 30 cm. Thus, the monitored channel (cut-off meander) affected (at its filling) the groundwater level at least to the distance of our measurement, i.e. 50 m from the channel.

The third experiment was carried out in the period 8 July to 29 July 2009 at locality C (Fig. 7) where three monitoring boreholes were prepared (perpendicular to the trapezoidal type of the channel – width in the channel crown 6.0 m and depth 1.7 m) and the fourth borehole additionally only after filling the channel. In the channel, the water level was increased by about 40 cm on 16 July. In boreholes 1 (1 m from the channel edge) and 2 (2 m from the channel), the water level increased nearly immediately to the water height in the channel, which took from 16 July to 20 July. In borehole 3 (5 m from the channel edge), the groundwater level was about 20 cm lower as against the water level in the channel. After the gradual lowering tjhe water level in the channel the experiment was terminated on 29 July, when the groundwater level was at the same level at all monitoring places as on 8 July at the beginning of the experiment. The level of water in borehole 4 was somewhat atypical at the end of the experiment when the progress of water lowering at this borehole was markedly slower. The water level in the

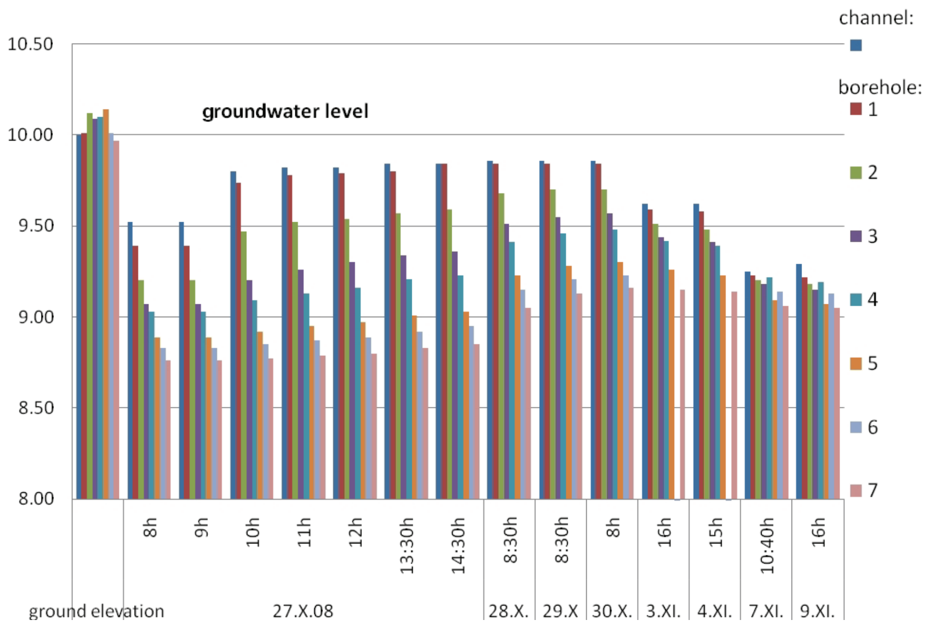

Fig. 6. Affecting the groundwater level by a channel at the Varadínek locality in the period 27 October to 9 November 2008.

channel and boreholes 1 to 4 is virtually identical at the beginning of the measurement 8 July and at the end of the experiment 29 July.

Through field experiments supported also by laboratory results of monitored soil samples taken in the channels, an original assumption has been confirmed that revitalization channels will have an important effect on the water balance in the nearest surroundings of the channels. With respect to differences in permeability conditions on the channel bed and slopes the level of water in channels is decisive. At the low water level, their effect on the soil profile moisture in the channel vicinity is minimal. At enhanced discharges in channels, the

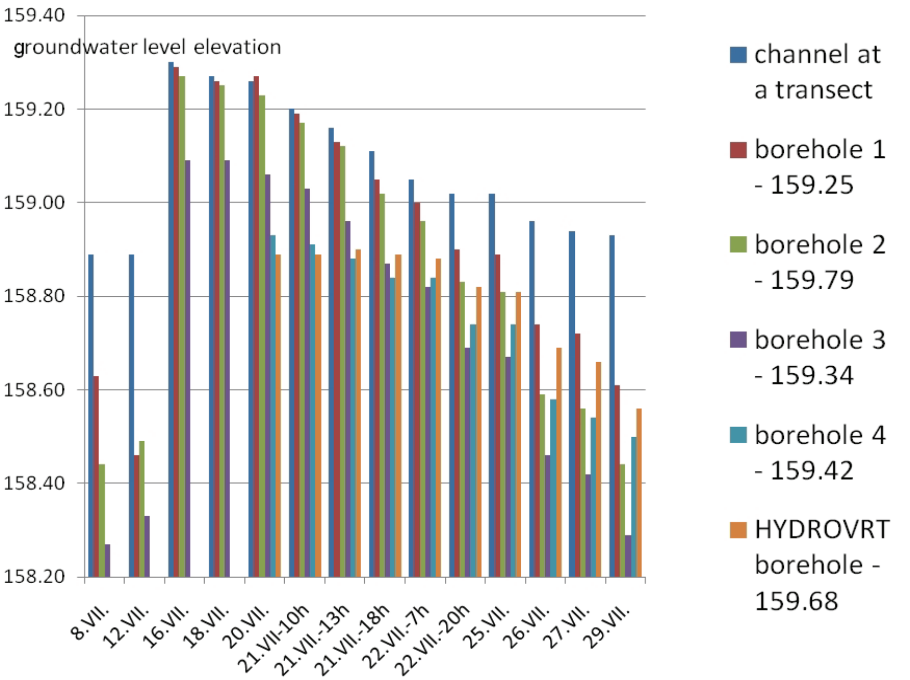

Fig. 7. Affecting the groundwater level by a channel at the Ladenská alej locality in the period 8 July to 29 July 2009.

gradual increasing of the groundwater level in the vicinity of revitalization channels occurs, namely up to a distance of several tens of metres during a few days.

Similar monitoring was carried out within the APOL project at Forest District Tvrdonice in 2002. It is described in the project final report (Prax P. et al., 2005). At assessing the effect of a revitalization system on the moisture regime of soils of a floodplain forest it is necessary to take into account that the richness of soil conditions (from sands up to clays) and complexity of the ground microrelief can affect "preferred roads" of groundwater, which flows through the floodplain beside the water body. At higher water level in the river it creates “power water” (artesian water) in heavy sediments. The power water occurs finally as undimmed in local terrain depressions and periodic pools.

At present at the Czech University of Life Sciences, Faculty of Environmental Sciences, Department of Land Use and Improvement, the selection of a suitable tool is carried out using mathematical-physical procedures, which could make possible to describe a hydrological event caused by field experiments discussed above. The use of motion equations is supposed, particularly certain forms of Boussinesque equation, to display the unsteady flow of groundwater in the saturated porous environment. Resulting expressions, which could be used, are derived from regularities of the groundwater flow mechanics in the saturated porous environment using the continuum axiom and Darcy law (Darcy, 1856) representing, together with the continuity equation, basic initial relationships. These procedures and suitably generated simplifying conditions will make possible to approximate and describe the groundwater flow caused by the effect of designed and realized technical measures (Štibinger, 2003, 2009). Verification of the accuracy of selected methods will be carried comparing modelled (forecasted) values with data obtained from field experiments. Possible deviations can be used to calibrate and adjust final results in such a way these relationships could be used in the area of science and in engineering water-management practice.

Conclusion

The largest complex of floodplain forests in the Czech Republic is situated above the confluence of the Morava and Dyje rivers. Natural conditions, which affected the floodplain ecosystem for a long time, were markedly disturbed by man in the 70s of the 20th century. After extensive water-management measures, both rivers including their local tributaries were channelized and diked. Formerly regularly repeating short-term floods were eliminated and the groundwater level was decreased. However, its important annual dynamics has been preserved. The impaired water balance resulted in the local die-back of mature forest stands of the floodplain forest in the period of a climatic dry spell in the 80s. In the 90s of the 20th century, Forest Enterprise Židlochovice implemented revitalization projects aimed at the improvement of the moisture regime of soils. Roughly after 15 years of the revitalization operation, checking the effect of revitalization channels was carried out. Through laboratory analyses of soil samples taken from the channel bed, their virtually minimum permeability was detected. Only after filling the channels, significant leakages into the surroundings occur, namely up to a distance of a few tens of meters during the period of several days. After spring maxima of the groundwater level, water in the channel can correspond with the surrounding groundwater. However, during the better part of the year, this connection is disturbed and an important stage of the soil environment oxidation proceeds and, thus also the soil air availability in the space of the relatively shallow root system of trees of a floodplain forest.

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