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Implementation of the Curve Number Method and the KINFIL Model in the Smeda Catchment to Mitigate Overland Flow with the Use of Terraces

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Abstract

Kovář P., Fedorova D., Bačinová H. (2018): Implementation of the curve number method and the KINFIL model in the Smeda Catchment to mitigate overland flow with the use of terraces. Soil & Water Res., 13: 98–107.

The Smeda catchment, where the Smeda Brook drains an area of about 26 km^2, is located in northern Bohemia in the Jizerské hory Mts. This experimental mountain catchment with the Bily Potok downstream gauge profile was selected as a model area for simulating extreme rainfall-runoff processes, using the KINFIL model supplemented by the Curve Number (CN) method. The combination of methods applied here consists of two parts. The first part is an application of the CN theory, where CN is correlated with hydraulic conductivity K_s of the soil types, and also with storage suction factor S_f at field capacity *FC:* CN = $f(K_s, S_f)$. The second part of the combined KINFIL/CN method, represented by the KINFIL model, is based on the kinematic wave method which, in combination with infiltration, mitigates the overland flow. This simulation was chosen as an alternative to an enormous amount of field measurements. The combination used here was shown to provide a successful method. However, practical application would require at least four sub-catchments, so that more terraces can be placed. The provision of effective measures will require more investment than is currently envisaged.

Keywords: CN method; infiltration; kinematic KINFIL model; wave

The discharges in the limnigraphic profile at the outlet of the Bily Potok profile of the Smeda catchment have been measured continuously since 1957. The physical and geometric characteristics of the catchment are provided in Table 1. The catchment area is 26.13 km^2.

MATERIAL AND METHODS

Smeda catchment. Table 2 presents the hydrological situation and the N-year discharges. Table 3 documents the calculation of the average value of the Curve Number CN$_{II}$ = 77.5. This value is relatively high, and indicates low infiltration capacity through the hydrologic soil group C (77%). The remainder of the soils belongs to the hydrologic group B, i.e. soils with low sorptivity (oligo-mesotrophic soils, podzolic peat-brown soils, and peaty-gley soils). The relative substitution of the first granulometric category is 20% to 25%, and the coefficient of saturated hydraulic conductivity K_s < 10 mm/h. The surface of the forested part of the catchment (88%) can be classified

Table 1. Physical and geometric characteristics of the Bily Potok profile of the Smeda catchment

Characteristics	Value
Catchment area (*AR*, km^2)	26.13
Length of talweg (*L*, m)	13 300
Slope of talweg (*J*, %)	6.9
Potential retention (*A*, mm)	74.0
Elevation (m a.s.l.)	403–990
Average width of the catchment (km)	1.96
Slope of the catchment (Herbst) (%)	22.2

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Table 2. *N*-year discharges from the Bily Potok profile in the Smeda catchment, (source Czech Hydrometeorological Institute, data 2015)

Return period (*N*-years)	1	2	5	10	20	50	100
Discharges Q_N (m^3/s)	21	33	54	74	97	132	162

Table 3. Curve Number (CN) for the Bily Potok profile in the Smeda catchment

Land use	Area (%)	Hydrol soil group	CN	Weighted mean CN
Forest	70	C	79	55.3
	18	B	69	12.4
Pastures	7	C	79	5.5
Arable land	3	B	79	2.4
Urbanized area	2	–	98	1.9
Total	100	–	–	77.5

under Forest Hydrological Conditions (FHC) = 2, on the basis of the compactness of "forest litter" when timber understorey (TU) = 1 (depth < 5 cm).

Since 1957, three rainfall observatories have been installed: at Hejnice, at Nove Mesto and at Bily Potok. All weighted rainfall means have also been measured, together with their direct discharge flows to the Smeda River at the Bily Potok catchment outlet. The basic characteristics of the catchment were derived from geographical maps, and are presented in Figure 1. For modelling rainfall – runoff, it is important to obtain correct values of the curve numbers (CN) (NRCS 2004a, b) as the starting values for the parameters of the model: hydraulic conductivities K_s, and the sorptivity values at the field capacities S_f. The values of CN are influenced by land use. In the the Smeda catchment, the land is used mainly for forestry.

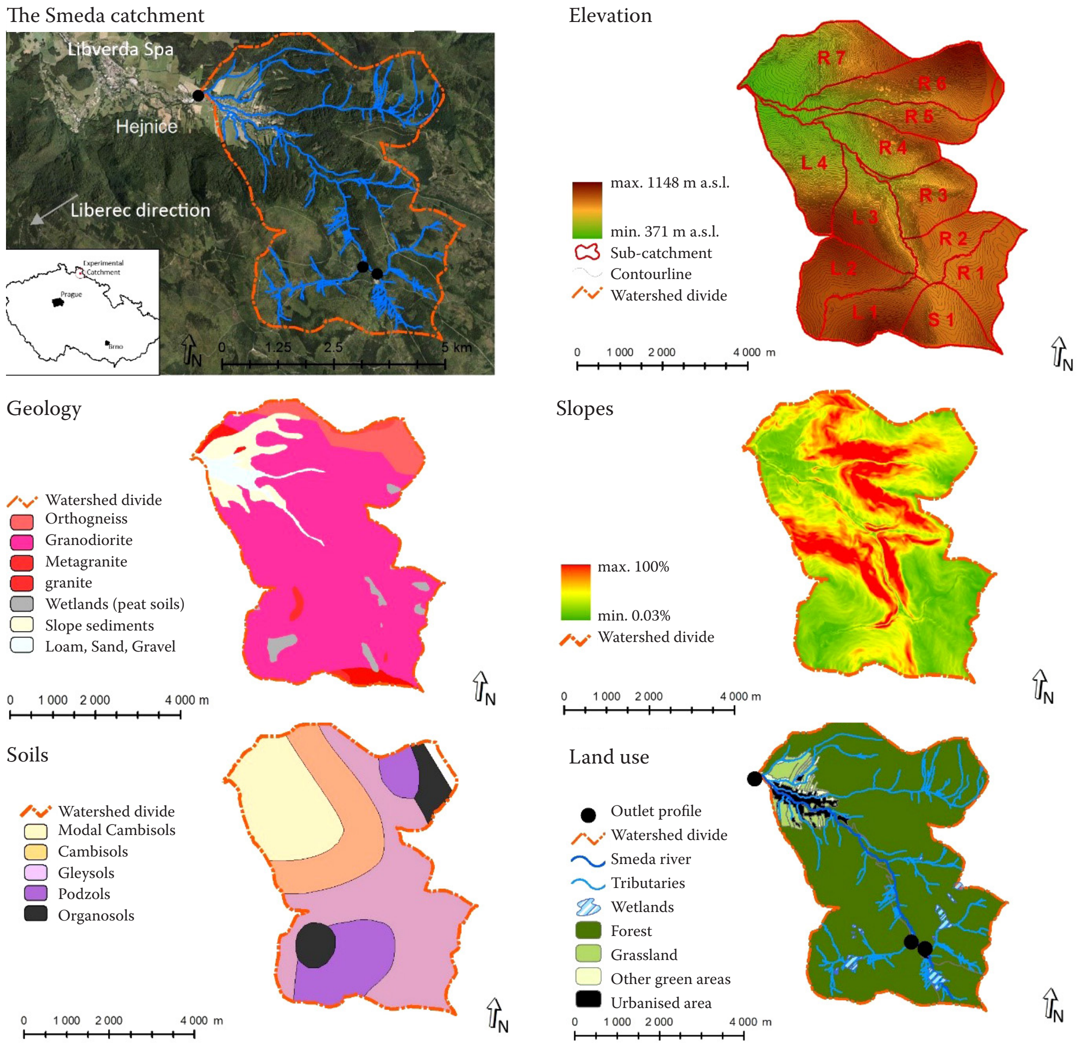

Figure 1. Selected characteristics of the Smeda catchment

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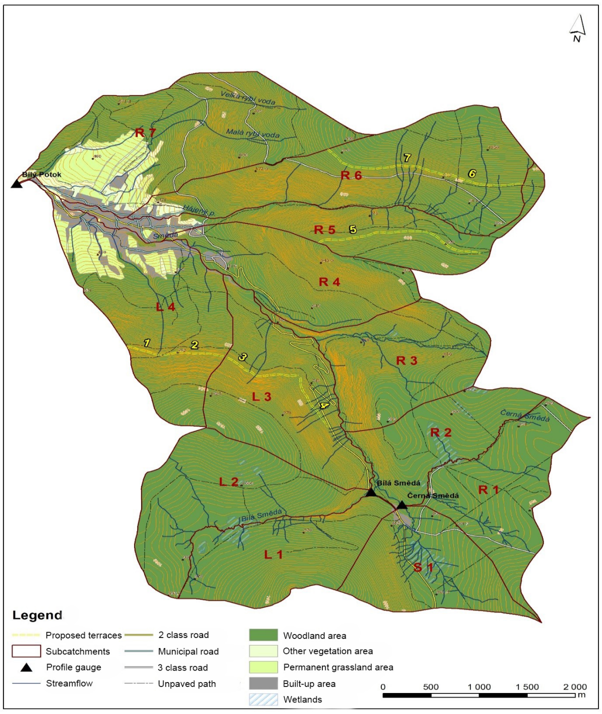

Figure 2. Design of the orderlines of each of the terraces in the Smeda catchment, sub-catchments R5, R6, L3 and L4

In addition, we optimized the design of the terraces for the simplest one-route, or three-routes, or five-routes in parallel. For this task, just four sub-catchments were selected. Sub-catchments R5, R6, and L3, L4 were designed. Unfortunately, the water discharges of the four sub-catchments (R5, R6 and L3, L4) in urbanized areas of the village of Bily Potok reach high values, despite the five rows of terraces (Figure 2).

Table 4 provides the parameters of standard flood control terraces, when they are 10.0 m in width and the central part is 5.0 to 7.0 m in length, with a slight slope of 0.01 to 0.03. The total sum of the lengths of all the terraces is 6488 m. Figure 3 presents the transversal profile of the terraces. It shows the comparability between filling and excavated parts of the natural soil material.

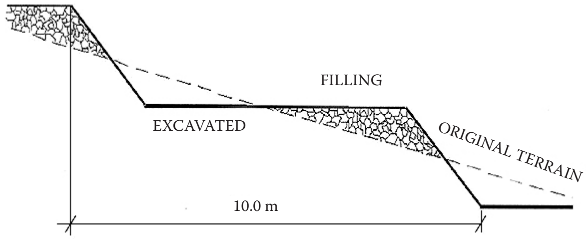

Figure 3. Transversal profile of the terraces designed for the Smeda catchment

Computations without the design of biotechnical measures were applied with short torrential rainfalls for a return period of $N = 2$, 10, and 100 years, and 40 min and 60 min in duration (Table 4), i.e. the conditions for which the critical culmination of the discharges was computed ($N = 2$ years is not printed here). The time translation of the runoff is dependent on travelling time T_L, which can be computed using the US SCS methodology (US SCS 1986, 1992), or according to FERGUSON (1998), as follows:

$$T_L = (3.28 \times L)0.8/1900 \times J_0^{0.5} \quad (1)$$

where:
L – hydraulic length of the thalweg (m)
J_0 – slope of the thalweg (%)
For CN = 77.5 the potential retention of the catchment A is 74.0 mm.

Natural gravel-bed channels are composed of heterogeneous sized grains at different spatial scales. MAO and SURIAN (2010) investigated sediment mobility and demonstrated the relationships between shear stress and sediment transform (LARONNE & SHLOMI 2007; CHANG & CHUNG 2012). An alternative method that has been recently developed in image processing techniques has shown promising as a viable method for measuring gravel and larger size fluvial sediment (BEGGAN & HAMILTON 2010). HALLEMA and MOUSSA (2014) used a distributed model for overland flow and channel flow based on a geomorphologic instantane-

Table 4. Standard flood control terrace parameters in the Smeda catchment

Terrace (n)	Sub-catchment (n)	Length (m)	Entire length (m)	Width (m)	Slope (–)	Roughness – Manning n (–)
5	R5	1794	1794	10.0	0.01	0.150
6 + 7	R6	684 + 1468	2152	10.0	0.01	0.150
3 + 4	L3	821 + 696	1517	10.0	0.01	0.150
1 + 2	L4	391 + 634	1025	10.0	0.01	0.150

Sum of lengths = 6488 m

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Table 5. Design rainfall depths $P_{t,N}$ (mm) and duration (min) for the Bily Potok observatory

N (years)	Rainfall duration (*t*, min)				
	24 h	20'	40'	60'	120'
2	66.8	27.16	32.74	35.47	40.70
5	95.0	41.37	52.07	56.40	64.65
10	113.1	51.67	65.50	70.94	81.24
20	132.0	64.04	81.90	88.71	101.52
50	155.1	79.82	103.61	112.23	128.82
100	173.2	92.15	120.00	129.98	148.91

ous unit hydrograph (GIUH) method. Quantification of the size distribution of fluvial gravels is an important issue in the studies of river channel behaviour in hydraulics, hydrology and geomorphology. For all the computations, we used our own DES_RAIN software (Vaššová & Kovář 2012), which is available on http://fzp.czu.cz/vyzkum/. Table 5 provides the design rainfall depths $P_{t,N}$ (mm) and the duration in minutes.

Combining the Curve Number method and the KINFIL model. A combination of the CN method and the KINFIL model (Kovar 1989, 2014) provides a schematic representation of the Smeda catchment data for the KINFIL model (Tables 6 and 7).

The current version of the KINFIL model is based on the Green-Ampt infiltration theory, with ponding time according to Mein and Larson (1973) and Morel-Seytoux (Morel-Seytoux & Verdin 1981; Morel-Seytoux 1982; Ponce & Hawkins 1996):

Table 6. Scheme of the Smeda catchment for the KINFIL model

Cascade/ subcatchment	Area (km^2)	Length of basin (km)	Plain	Area (km^2)	Average width (km)	Length (km)	Slope (–)	Grass land (%)	Forest (%)	Other area (%)	Built-up area (%)
S1	1.64	1.86	S 11	1.12	0.88	1.26	0.178	0.00	99.30	0.00	0.70
			S 12	0.53		0.60	0.114	0.00	94.60	0.00	5.40
R1	1.84	1.35	R 1	1.84	1.36	1.35	0.070	0.00	99.60	0.00	0.40
R2	1.44	0.75	R 21	0.96	1.93	0.50	0.097	0.00	99.60	0.00	0.40
			R 22	0.48		0.25	0.204	0.00	99.90	0.00	0.10
R3	1.99	1.80	R 31	1.08	1.10	0.98	0.213	0.00	100.00	0.00	0.00
			R 32	0.91		0.83	0.394	0.00	99.90	0.00	0.10
R4	1.91	1.75	R 41	0.97	1.09	0.89	0.243	0.80	91.50	0.00	7.80
			R 42	0.95		0.87	0.424	0.00	100.00	0.00	0.00
R5	1.79	0.78	R 51	0.10	2.29	0.05	0.119	0.00	100.00	0.00	0.00
			R 52	0.41		0.18	0.216	0.00	100.00	0.00	0.00
			R 53	1.27		0.56	0.269	1.10	81.10	1.70	16.10
R6	3.3	1.49	R 61	0.50	2.22	0.23	0.156	0.00	100.00	0.00	0.00
			R 62	1.33		0.60	0.218	0.00	100.00	0.00	0.00
			R 63	1.47		0.66	0.380	0.65	93.75	3.06	2.54
R7	3.46	3.50	R 71	0.40	0.99	0.41	0.180	0.00	100.00	0.00	0.00
			R 72	1.68		1.70	0.317	2.90	95.40	1.70	0.00
			R 73	1.38		1.40	0.147	34.70	42.50	15.00	7.80
L1	1.79	1.18	L 11	0.62	1.51	0.41	0.193	0.00	100.00	0.00	0.00
			L 12	1.17		0.77	0.147	0.00	99.70	0.00	0.30
L2	2.25	1.23	L 21	1.34	1.83	0.73	0.086	0.00	100.00	0.00	0.00
			L 22	0.91		0.50	0.154	0.00	99.93	0.00	0.07
L3	2.33	1.48	L 31	0.36	1.58	0.23	0.157	0.00	100.00	0.00	0.00
			L 32	1.61		1.02	0.415	0.00	98.40	0.00	1.60
			L 33	0.36		0.23	0.273	0.00	94.60	0.00	5.40
L4	2.75	2.67	L 41	0.23	1.03	0.23	0.171	0.00	100.00	0.00	0.00
			L 42	1.03		1.00	0.403	0.00	100.00	0.00	0.00
			L 43	1.49		1.45	0.164	24.70	52.00	2.00	21.30

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Table 7. Correlation relationships CN = $f(K_s, S_f)$, orderlines of the terraced area

Status	Number of lines	CN (–)	K_s (mm/h)	S_f (mm)	Terraces area	
					(km^2)	(%)
Without terraces	–	77	1.86	22.60	–	–
	1	75	2.02	20.75	0.423	1.61
With terraces	3	71	3.63	18.34	1.270	4.86
	5	67	5.20	16.60	2.120	8.11

CN – Curve Number; K_s – hydraulic conductivity; S_f – storage suction factor

$$K_s\,(z_f + H_f/z_f) = (\theta_s - \theta_i)dz_f/dt \quad (2)$$

$$S_f = (\theta_s - \theta_i) \times H_f \quad (3)$$

$$t_p = S_f/i \times (i/K_s - 1) \quad (4)$$

where:
K_s – hydraulic conductivity (m/s)
z_f – the vertical extent of the saturated zone (m)
θ_s – water content at natural saturation (–)
θ_i – initial water content (–)
H_f – wetting front suction (m)
I – rainfall intensity (m/s)
S_f – storage suction factor (m)
t_p – ponding time (s)
t – time (s)

The main task is to assess hydraulic conductivity K_s, and the storage suction factor S_f (at field capacity, *FC*). These two parameters can be measured directly on small experimental catchments. In larger catchments, the previously derived relationships of these parameters and the CN, which are widely used by Soil Conservation Service (SCS) (US SCS 1986), can also be applied. The CN correspond with the conceptual values of soil parameters K_s and S_f (*FC*): CN = $f(K_s, S_f)$.

The CN method, developed by the US Soil Conservation Service based on soil types (Brakensiek & Rawls 1981), design rainfall depths and duration, vegetation cover, land use, and antecedent moisture conditions, is widely used due to its easy application. An evident shortcoming of this methodology is that it disregards both the intensity and the duration of the rainfall that causes flood runoff. This imperfection can be dealt with by using the physically-based infiltration approach of the KINFIL model (Kovář 1992) instead of the usual empirical CN approach. The relationships between the CN method and the soil type parameters have been used for the infiltration process. These relationships were derived by correlating the data from 62 gauges located in the Czech territory (Šamaj *et al.* 1983; Kovář 1992) and the parameters of the basic soil groups.

RESULTS AND DISCUSSION

The computed CN values for the Smeda catchment are shown in Table 8.

Table 9 shows the principles for computing the results from the correlation processes to change the hydraulic conductivity K_s (mm/h) and the sorptivity $S(\theta_{FC})$ (mm/h$^{0.5}$ at field capacity). When this sorptivity $S(\theta_{FC})$ is amended to the storage suction factor, its form can be expressed as follows:

$$S_f = (S(\theta_{FC})^2/2.0 \times K_s) \quad (5)$$

The second part of the KINFIL model simulates the propagation and the transformation of the direct runoff (Beven 2006). The partial differential equation describes the unsteady flow approximated by a kinematic wave on a cascade of planes arranged according to the topography of the catchment:

$$\frac{\partial y}{\partial t} + \alpha m y^{m-1} \times \frac{\partial y}{\partial x} = i_e(t) \quad (6)$$

Table 8. Curve Number (CN) values derived from the Smeda catchment for the soil types (US classification and Czech Bily Potok major profile)

	Soil types									
	1	2	3	4	5	6	7	8	9	10
CN	95.1	92.1	90.0	86.8	85.8	78.0	64.1	60.7		

US soil types (Brakensiek and Rawls (1981), amended by the Czech soil classification according to Novak)

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Table 9. Instruction from the correlation processes for hydraulic conductivity K_s (mm/h) and storage suction factor S_f (mm)

Conditions for CN	Equation	Accuracy (σ)
K_s equations (mm/h)		
if CN ≥ 75	$K_s = \frac{100 - CN}{12 \times 4}$	0.084
if 74 ≥ CN < 36	$K_s = 31.4 - (0.39 \times CN)$	0.136
if CN < 35	$K_s = 47.1 - (0.82 \times CN)$	
$S(\theta_{FC})$ equations (mm/h$^{0.5}$)		
if CN > 65	$S(\theta_{FC}) = \frac{100 - CN}{2.5}$	
if CN < 64	$S(\theta_{FC}) = 30.25 - (0.15 \times CN)$	

CN – Curve Number; $S_f = S(\theta_{FC})^2/2.0 \times K_s$

where:
x, y, t – length (m), depth (m) and time (s)
α, m – hydraulic parameters
$i_e(t)$ – excess rainfall intensity (m/s)

This equation is solved by the finite difference method, using an explicit numerical scheme. Numerical stability of the scheme is ensured if the time and space step is according to equation (7):

$$c\frac{\Delta t}{\Delta x} \leq 1 \tag{7}$$

where:
c – celerity
$c = m \times y^{m-1}$
y – water depth

Explicit schemes in the software where there is only one unknown on the left-hand side of the equation are quick, but they are sensitive to the stability of the computation, if there is a bigger difference in the time (Δt) and space step (Δx) (Eq. (7)).

To ensure safe biotechnical measures, it is necessary to construct multiple terraces in a contour line system. In the Smeda basin, one row 10 m in width has been built in four sub-catchments R5, R6, and L3, L4. For a greater level of safety, the Bily Potok municipality will need at least five rows of terraces to decrease the water discharges for N = 10-year flood from 67.0 m^3/s (without terraces) to about 64.5 m^3/s. The Tables 10–13 and Figures 4 and 5 provide results that reduce the cumulation of N =100-year discharges from 167.3 m^3/s (without terraces) to about 162.0 m^3/s. The most dangerous time situation is duration of 40 min. A similar computation was also performed for a torrential rain of 60 min in duration, but this is a less dangerous scenario.

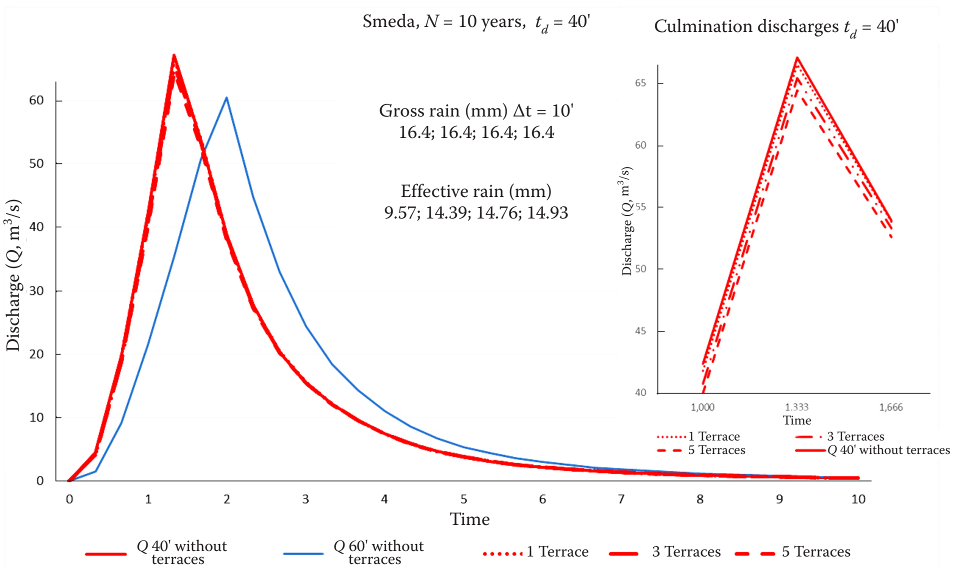

Figure 4. Smeda, N = 10 years, time duration t_d = 40 min; discharges without terraces, 1 terrace, 3 terraces, 5 terraces

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Table 10. Maximum N = 10 years and N = 100 years discharges (Q, m^3/s) with duration of 40 min, without terraces and with 5 rows of terraces

Seq.	Time (h)	10 years		100 years		Seq.	Time (h)	10 years		100 years	
		without terraces	5 rows of terraces	without terraces	5 rows of terraces			without terraces	5 rows of terraces	without terraces	5 rows of terraces
1	0.333	4.461	4.252	19.226	17.906	16	5.333	3.164	3.149	3.368	3.353
2	0.666	20.023	18.913	69.224	64.570	17	5.666	2.643	2.631	2.789	2.776
3	1.000	42.347	40.005	129.138	123.765	18	6.000	2.235	2.225	2.339	2.329
4	1.333	67.069	64.454	167.356	161.927	19	6.333	1.909	1.900	1.983	1.974
5	1.666	53.926	52.618	105.956	103.828	20	6.666	1.644	1.637	1.698	1.690
6	2.000	38.737	38.091	67.480	66.622	21	7.000	1.427	1.421	1.466	1.460
7	2.333	27.635	27.296	44.925	44.524	22	7.333	1.248	1.242	1.275	1.269
8	2.666	20.400	20.205	30.333	30.117	23	7.666	1.097	1.092	1.117	1.112
9	3.000	15.540	15.419	20.845	20.715	24	8.000	0.970	0.966	0.985	0.981
10	3.333	12.181	12.101	14.843	14.759	25	8.333	0.862	0.858	0.874	0.870
11	3.666	9.580	9.524	10.963	10.905	26	8.666	0.769	0.766	0.779	0.776
12	4.000	7.507	7.466	8.332	8.290	27	9.000	0.690	0.687	0.699	0.696
13	4.333	5.920	5.889	6.476	6.444	28	9.333	0.622	0.619	0.629	0.626
14	4.666	4.735	4.711	5.127	5.103	29	9.666	0.563	0.561	0.569	0.567
15	5.000	3.843	3.824	4.125	4.106	30	10.000	0.512	0.510	0.517	0.515

Seq. – sequence

Table 11. Effectiveness of the terraces in the Smeda catchment, N = 10 and 100 years, time duration t_d = 40 and 60 min (effective rainfall; 5 rows of terraces)

Without terraces	With terraces	Without terraces	With terraces
N = 10, t_d = 40': RER = 56.7 mm	RER_T = 55.9 mm	N = 100, t_d = 40': RER = 112.2 mm	RER_T = 110.4 mm
N = 10, t_d = 60': RER = 59.7 mm	RER_T = 58.7 mm	N = 100, t_d = 60': RER = 118.8 mm	RER_T = 117.8 mm

RER – effective rainfall without terraces (mm); RER_T – effective rainfall with terraces (mm)

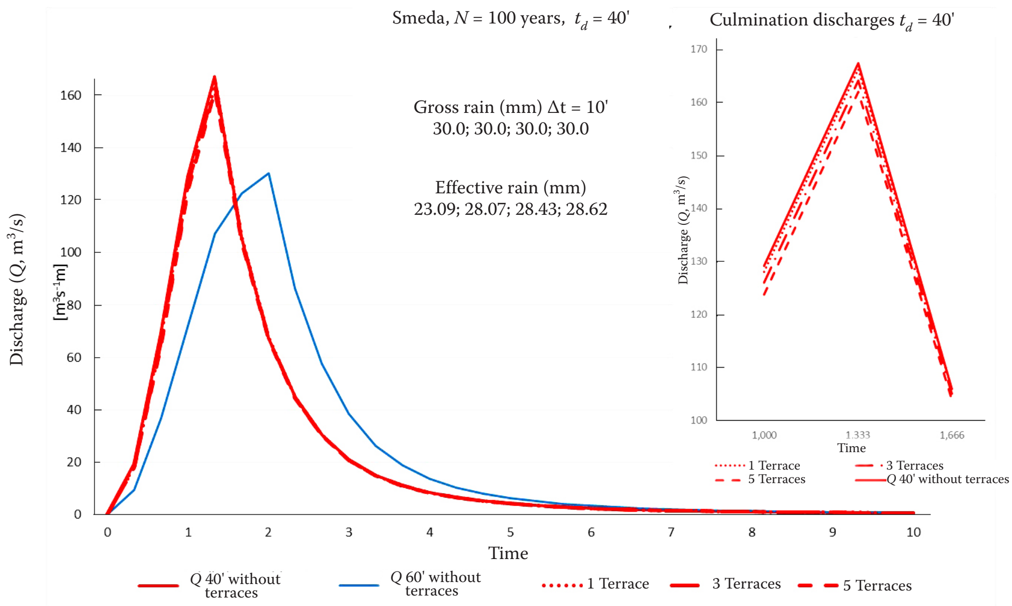

Figure 5. Smeda, N = 100 years, time duration t_d = 40 min; discharges without terraces, 1 terrace, 3 terraces, 5 terraces

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Table 12. Discharges (Q, m^3/s) from individual sub-catchments of the Smeda catchment, N = 10 years, time duration 40 min

S1-2	R1-1	R2-2	R3-2	R4-2	R5-3	R6-3	R7-3	L1-2	L2-2	L3-3	L4-3
0.201	0.244	0.296	0.234	0.241	0.802	0.464	0.257	0.393	0.487	0.559	0.282
0.932	1.128	1.380	1.083	1.113	3.704	2.146	1.190	1.815	2.248	2.041	1.243
2.006	2.516	3.735	2.410	2.491	7.061	4.890	2.654	4.085	4.549	3.979	1.971
2.884	4.334	5.836	3.958	4.863	7.460	10.448	4.548	6.985	7.155	6.578	2.021
2.453	4.199	3.802	3.407	5.417	3.675	9.522	4.253	4.619	5.718	5.954	0.908
2.220	3.615	2.227	3.079	4.055	1.788	6.475	3.726	2.856	3.864	4.434	0.398
2.116	2.717	1.327	2.810	2.700	0.937	4.184	3.431	1.753	2.535	2.932	0.194
1.820	1.923	0.824	2.407	1.828	0.538	2.772	3.375	1.104	1.701	2.003	0.106
1.446	1.365	0.537	1.875	1.264	0.334	1.889	3.456	0.727	1.174	1.409	0.065
1.115	0.994	0.368	1.436	0.904	0.222	1.336	3.418	0.501	0.835	1.011	0.042
0.860	0.743	0.262	1.103	0.664	0.155	0.975	3.075	0.359	0.612	0.741	0.029
0.673	0.569	0.194	0.862	0.500	0.113	0.732	2.557	0.266	0.461	0.558	0.021
0.534	0.444	0.148	0.686	0.388	0.086	0.565	2.066	0.203	0.356	0.429	0.016
0.431	0.353	0.115	0.554	0.307	0.066	0.445	1.675	0.159	0.280	0.337	0.012
0.353	0.285	0.092	0.453	0.246	0.053	0.356	1.373	0.127	0.225	0.270	0.010
0.293	0.234	0.074	0.376	0.200	0.043	0.289	1.141	0.103	0.184	0.219	0.008
0.245	0.195	0.061	0.315	0.165	0.035	0.239	0.964	0.085	0.152	0.181	0.006
0.207	0.165	0.051	0.267	0.138	0.029	0.200	0.823	0.070	0.127	0.151	0.005
0.177	0.140	0.043	0.228	0.117	0.025	0.170	0.709	0.059	0.108	0.128	0.005
0.153	0.121	0.037	0.196	0.101	0.021	0.145	0.615	0.051	0.092	0.110	0.004
0.133	0.105	0.032	0.170	0.087	0.018	0.125	0.537	0.043	0.080	0.095	0.003
0.116	0.091	0.028	0.148	0.076	0.016	0.109	0.471	0.038	0.070	0.083	0.003
0.102	0.080	0.024	0.131	0.066	0.014	0.095	0.416	0.033	0.061	0.073	0.003
0.091	0.070	0.021	0.116	0.058	0.012	0.084	0.368	0.029	0.054	0.064	0.002
0.081	0.062	0.019	0.103	0.051	0.011	0.074	0.327	0.026	0.048	0.057	0.002
0.072	0.055	0.017	0.093	0.046	0.009	0.066	0.292	0.023	0.043	0.051	0.002
0.065	0.050	0.015	0.083	0.041	0.008	0.059	0.263	0.021	0.038	0.045	0.002
0.059	0.044	0.014	0.075	0.037	0.008	0.054	0.237	0.019	0.035	0.041	0.001
0.053	0.040	0.012	0.068	0.033	0.007	0.048	0.215	0.017	0.031	0.037	0.001
0.048	0.036	0.011	0.062	0.030	0.006	0.044	0.196	0.015	0.028	0.033	0.001

For a comparison with the N-year discharges on the Smeda catchment, we computed Tables and Figures with geometric factors for sub-catchments and their land use. The same procedure was followed, in principle, for N = 2 years and 40 min duration. However, this computation is not presented here.

CONCLUSION

Slope terraces have hydro-physical characteristics that can be different and they require a lot of finances. Hydrological analyses indicate that the use of flood control terraces as biotechnical measures does not provide any effective barriers for the Bily Potok municipality. For a practical application, more than four sub-catchments are needed. In addition, more than five rows of terraces are needed, and also at least two polders. The provision of effective measures will require more investment than is currently envisaged. A comparison of the computational results (Table 10) shows that correct results are dependent on regular maintenance.

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Table 13. Discharges (Q, m^3/s) from individual sub-catchments of the Smeda catchment, N = 100 years, time duration 40 min

S1-2	R1-1	R2-2	R3-2	R4-2	R5-3	R6-3	R7-3	L1-2	L2-2	L3-3	L4-3
0.877	1.062	1.287	1.019	1.048	3.493	2.020	1.121	1.709	2.120	2.317	1.153
3.268	4.008	5.767	3.844	3.957	12.294	7.670	4.228	6.468	7.571	6.486	3.664
5.556	8.368	11.138	7.618	9.490	14.215	20.231	8.777	13.384	13.496	12.711	3.954
8.380	13.102	11.455	11.178	15.085	14.356	26.099	13.347	14.083	17.831	18.556	3.884
6.945	9.489	6.230	9.571	9.879	5.669	16.535	11.851	7.712	9.868	10.862	1.347
5.391	5.927	3.123	7.031	6.118	2.305	9.584	11.081	4.091	5.736	6.605	0.488
3.757	3.734	1.657	4.863	3.647	1.089	5.539	10.776	2.220	3.401	4.026	0.216
2.600	2.432	0.955	3.363	2.274	0.590	3.374	8.705	1.295	2.104	2.527	0.114
1.844	1.642	0.595	2.386	1.484	0.355	2.181	6.457	0.811	1.370	1.653	0.067
1.341	1.151	0.396	1.732	1.014	0.232	1.487	4.837	0.541	0.937	1.130	0.044
1.000	0.837	0.277	1.289	0.724	0.161	1.058	3.735	0.379	0.668	0.804	0.030
0.762	0.626	0.203	0.981	0.535	0.116	0.780	2.942	0.277	0.494	0.593	0.022
0.594	0.481	0.153	0.764	0.407	0.087	0.592	2.347	0.209	0.376	0.450	0.016
0.472	0.377	0.118	0.606	0.318	0.067	0.461	1.890	0.162	0.293	0.350	0.012
0.382	0.301	0.094	0.489	0.254	0.053	0.366	1.537	0.129	0.233	0.278	0.010
0.313	0.245	0.076	0.401	0.206	0.043	0.297	1.263	0.104	0.189	0.225	0.008
0.260	0.202	0.062	0.332	0.170	0.035	0.244	1.051	0.086	0.156	0.185	0.006
0.219	0.169	0.052	0.279	0.142	0.029	0.204	0.885	0.071	0.130	0.154	0.005
0.186	0.143	0.044	0.237	0.119	0.025	0.172	0.753	0.060	0.110	0.131	0.005
0.159	0.123	0.037	0.203	0.102	0.021	0.147	0.646	0.051	0.094	0.112	0.004
0.137	0.106	0.032	0.175	0.088	0.018	0.126	0.558	0.044	0.081	0.097	0.003
0.119	0.093	0.028	0.153	0.076	0.016	0.110	0.485	0.038	0.070	0.084	0.003
0.105	0.081	0.024	0.134	0.067	0.014	0.096	0.425	0.033	0.061	0.074	0.003
0.092	0.072	0.021	0.118	0.059	0.012	0.084	0.375	0.029	0.054	0.066	0.002
0.082	0.064	0.019	0.105	0.052	0.011	0.075	0.332	0.026	0.048	0.058	0.002
0.073	0.057	0.017	0.094	0.046	0.009	0.067	0.296	0.023	0.043	0.052	0.002
0.066	0.052	0.015	0.084	0.041	0.008	0.060	0.265	0.021	0.038	0.047	0.002
0.059	0.047	0.014	0.076	0.037	0.007	0.054	0.239	0.019	0.034	0.042	0.001
0.054	0.042	0.012	0.069	0.034	0.007	0.049	0.216	0.017	0.031	0.038	0.001
0.049	0.038	0.011	0.063	0.031	0.006	0.044	0.197	0.015	0.028	0.034	0.001

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