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EROSION ASPECT IN ESTIMATION OF HYDROLOGIC SOIL GROUP AND DETERMINATION OF RUNOFF CURVE NUMBER CN

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Computation of maximal discharge Qmax(%), on torrential catchment areas, is carried out, usually, by synthetic unit hydrograph (maximal ordinate of synthetic unit hydrograph) and SCS method (deriving of effective rainfall Pe from total precipitation Pb). Calculation of effective rainfall is based on determination of runoff curve number CN. Runoff curve number depends on: hydrologic soil group; hydrologic conditions; land use. Erroneous estimations of hydrologic group of soil and hydrologic conditions, especially on the terrain with developed erosion processes, lead to successive errors: runoff curve number CN→potential maximum retention d → effective rainfall Pe → maximal discharge Qmax. Adequate procedure for estimation of runoff curve number CN

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was applied in the experimental catchment area of river Onjeg (subcatchment of the Kolubara river system), at the profile Brajkovac.

Key words: erosion processes; runoff curve number; hydrologic conditions; maximal discharge

INTRODUCTION

Erosion control works on the regulation of torrent beds are related to building of longitudinal and transversal structures. Basic input datum for projecting of these objects is maximal discharge of desired probability. Combined usage of synthetic unit hydrograph and SCS methodology (deriving effective rain Pe from total precipitation Pb) is the most frequent procedure in the hydrology of torrential, unstudied catchment areas. Determination of effective rain Pe is very important part of computation, based on previously defined runoff curve number - CN. Erroneous estimation of CN causes successive errors in calculation with finally unadequate value of maximal discharge Qmax. It seriously endangers the safety of longitudinal and transversal structures in torrential beds.

$$Q_{\max} = q_{\max} \cdot Pe \qquad [m^3 s^{-1}] \qquad (1)$$

$q_{\max}$ maximal ordinate of unit hydrograph $[m^3 s^{-1} mm^{-1}]$

Pe effective rain $[mm]$

$$P_e = \frac{(P_b - 0.2d)^2}{P_b + 0.8d} \qquad (2)$$

P_b - total precipitation $[mm]$

$$d = (\frac{1000}{CN} - 10) \cdot 25.4 \qquad [mm] \qquad (3)$$

d - potential maximal retention

RUNOFF CURVE NUMBER - CN

Infiltration of surface water into soil depends on the following factors: land use, characteristics of vegetation cover, air and water capacity of soil. Initial abstraction could include total precipitation (in the stable forest stands with developed soil profile, even rainfall of strong intensity with total amount over 100 mm). Presence of vegetation increases surface roughness, reduces velocity of surface runoff and prolongs time characteristics of hydrograph (time of rising; time of recession; lag time; concentration time).

SCS methodology is used for calculation of effective rain Pe. Key parameter, besides datum of total precipitation Pb, is runoff curve number - CN. Processing of CN contains a few levels of uncertainty, with possible errors:

- determination of hydrologic soil group (A, B, C, D) is usually done on the basis of (un) known qualitative characteristics of soil. Hydrologic groups of soil could be determined by SCS criterion (minimal amount of infiltrated water per one hour). Hydrologic soil groups were not determined systematically for the whole territory of Serbia. Classification of hydrologic soil groups were carried out in USA, after detailed field investigations with usage of infiltration measuring apparatus. Result of investigation is map of USA with 4000 types of soil (SCS, 1972), with signed hydrology groups (A,B,C, D). In such a way, hazard of arbitrary estimation was completely eliminated. List with the most important types of soil and belonging hydrologic groups have been used in hydrological practice of Serbia. The list was formed on the basis of knowledge of infiltration characteristics of certain types of soil which was funded on reach experience of investigator and engineer in the domain of melioration (DJOROVIĆ, 1984). The list represents a remarkable contribution to hydrological practice in Serbia, and more than 17 years was used in the procedure of determination of runoff curve number - CN. The list was formed for completely defined characteristic types of soil, but it is possible to find out soil layers at certain level of development, or on the border between two types. If the designer is not sufficiently experienced in soil science (it is very often), or if field investigation of catchment area is missing, error in estimation of hydrologic group of soil could be expected. If type of soil, signed on the map, is present on the terrain, error is possible if soil profile is in degradation phase under impact of erosion and has to be classified in lower group.

- determination of structure of surfaces in the catchment area (land use) is usually done on the basis of topographic maps R=1:25000, and very often R=1:50000, or on the cadastre (real estate registry). Both ways are extremely unreliable, because conditions on the map are often related to periods of a few decades ago, and somewhat better situation is with cadastre.

- determination of hydrological conditions on the basis of estimation. Hydrological conditions could be poor, fair and good, but many designers have not an idea about real meaning of these notions. Assuming that hydrologic soil groups were determined correctly, and the cadastre was recently reconstructed, field investigations are necessary in order to estimate hydrological conditions. Criterions for determination of hydrological conditions are different for agricultural land, forest, pastures and meadows. For example, correct determination of hydrological conditions on surfaces covered by forest vegetation needs the following data: cover density; presence or absence of litter; structure of vegetation in the ground floor; usage of forest for grazing or not; degree of degradation by fire, etc. (SCS, 1972). Different types of forest soil are frequently placed in mosaic, and even identical types of soil have changed characteristics under impact of stand factors (BURLICA, Č., 1972). Hydrological conditions on agricultural land directly depends on erosion aspect (SR-straight row farming, accelerates sheet and furrow erosion; C-contour farming, decelerates erosion; T-terracing, significantly reduces the intensity of erosion processes)

Three above mentioned levels of uncertainty could be minimized under the following circumstances: classification of hydrologic soil groups in Serbia on the basis of field investigations (usage of infiltrometer); detailed mapping of surfaces (land use) and erosion processes on studied catchment area (RISTIĆ, 2000).

MATERIAL AND METHOD

Importance of objective estimation of runoff curve number CN is illustrated on the example of experimental catchment area of river Onjeg, at profile Brajkovac. River Onjeg belongs to Kolubara river system, and profile Brajkovac is near by city Lazarevac. Investigation was carried out as basis for planning earthfill dam for water supply, with useful height of 22 m. Detailed field investigation was necessary in order to register erosion processes on the catchment area, and estimate possible deposition of sediment in further accumulation. Precise mapping was done, with deriving 64 erosive block-parcels, under characteristic type of erosion process, vegetation cover and land use. Registering was carried out during field investigation (21. 04. - 23. 04. 2000.), with usage of four-colored topographic maps. Erosion production was estimated by method of coefficients (GAVRILOVIĆ, 1972).

Table 1. - Structure of surfaces (land use) in the catchment area of river Onjeg

Surface	km²	%
Forest	8.99	39.43
Plowed fields	8.76	38.42
Meadows	1.57	6.89
Pastures	1.04	4.56
Orchards	1.5	6.58
Farmsteads	0.94	4.12
Total:	22.8	100

The greater part of the catchment area is under brown-skeleton soil (16.86 km²). This type of soil belongs to hydrologic group B. Pseudogley covers 5.94 km² of the catchment area and belongs to hydrologic group C.

RESULTS AND DISCUSSION

Calculation of maximal discharge was done for probability p=1% (once in 100 years). Synthetic unit hydrograph (maximal ordinate of unit runoff q_{max}) and SCS methodology (deriving effective rain P_e from total precipitation P_b) were applied. Data about maximal daily precipitation were provided from rain-gauge station Dudovica (135 meters above sea level).

Table 2. - Main hydrographic characteristics of river Onjeg catchment area

-Parameter	Mark	Unit	Value
-Magnitude	A	km2	22.8
-Peak point	Kv	a.s.l.	479
-Confluence point	Ku	a.s.l.	195
-Length of the main stream	L	km	8.68
-Distance from the outlet to a point on the stream nearest the centroid of the catchment area	Lc	km	4.1
-Absolute slope of river bed	Ia	%	3.27
-Average slope of river bed	Iu	%	1.44

Antecedent moisture condition was supposed as AMC-III (AMC was estimated from 5-days antecedent rainfall in growing season, over 53.34 mm; highest water potential, when catchment area is practically saturated by antecedent rains).

Table 3. - Results of calculation of maximal discharge, in two variants

I variant, CN=68.88	Pe(1%)=23.49 mm	Qmax(1%)=32.38 $m3.s^{-1}$
II variant, CN=73.07	Pe(1%)=26.95 mm	Qmax(1%)=38.70 $m3.s^{-1}$

Hydrographs of direct runoff (both variants) are presented in Figure 1. Maximal discharges for both variants are presented in Table 3 (input data were identical: L, Lc, Iu, tp-lag time, Pb). Maximal discharges differ about 16%, also volumes in similar proportion. Values of effective rain were computed for two values of runoff curve number - CN. In the first variant, runoff curve number (CN=68.88) was determined by usage of topographic map R=1:25000, and detailed field investigation. In the second variant, runoff curve number (CN=73.07 was determined with additional discussion about hydrological conditions. Hydrological conditions (poor, fair, good) were discussed from the aspect of intensity of present erosion processes, in accordance with SCS criterions (for each derived erosive block-parcel).

Table 4. List of erosive block-parcels with estimated values of runoff curve number - CN

Parcel N°	Magnitude (km^2)	CN (I variant)	CN (II variant)
1	0.042	55	70
2	0.099	75	82
3	0.090	55	77
4	0.192	60	60
5	0.101	60	60
6	0.105	67	73
7	0.048	60	60
8	0.051	35	67
9	0.036	75	74
10	0.078	55	66
11	0.048	35	35
12	0.147	67	67
13	0.031	73	73
14	0.300	73	73
15	0.276	55	66
16	0.663	82	82
17	0.225	74	74
18	0.691	35	59
19	0.163	82	82
20	0.504	70	70
21	1.203	73	73
22	0.166	73	73
23	0.688	81	81
24	0.120	81	81
25	1.432	73	73
26	0.072	82	82
27	1.894	73	73
28	0.102	82	82
29	0.090	81	81
30	0.150	85	85
31	0.270	55	77
32	0.054	70	76
33	0.270	70	76
34	0.909	70	76
35	0.723	70	76
36	0.480	69	69
37	0.180	60	60
38	0.174	74	74
39	0.210	67	73
40	0.366	60	60

41	0.210	70	76
42	0.492	73	73
43	0.120	60	60
44	0.270	60	60
45	0.132	60	60
46	0.585	60	60
47	0.426	60	60
48	0.546	70	76
49	0.822	70	76
50	0.192	60	60
51	0.967	60	60
52	0.150	60	60
53	0.276	60	60
54	0.240	70	76
55	0.402	70	76
56	0.180	70	76
57	0.282	60	60
58	0.357	70	76
59	0.603	60	60
60	0.668	70	76
61	0.246	70	76
62	0.516	60	60
63	0.150	60	60
64	0.204	55	77
Total	22.80	CNm=68.88	CNm=73.07

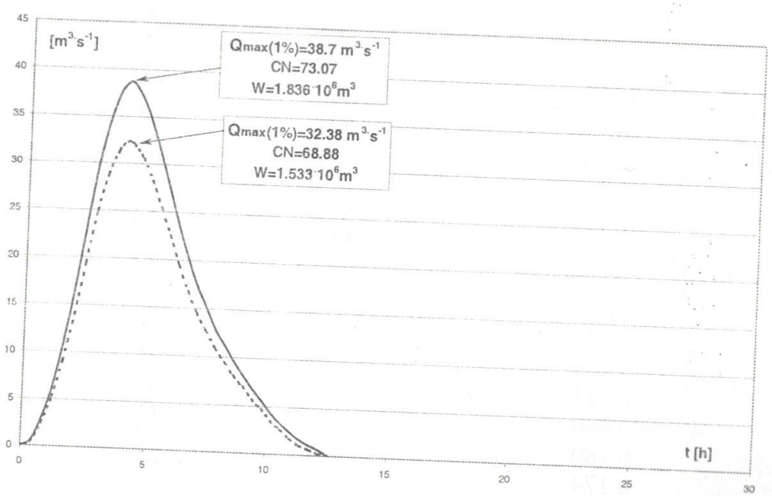

Figure 1- Hydrographs of direct runoff (I and II variant)

CONCLUSIONS

Runoff curve number - CN impacts on values of effective rain Pe and maximal discharge Qmax. Computation of maximal discharge could be the source of serious errors, if detailed field investigation with mapping and estimation of hydrological conditions from erosion aspect are missing. Wrong procedure of runoff curve number - CN determination leads to successive errors and final product is unadequate value of maximal discharge Qmax. It seriously endangers safety of longitudinal and transversal objects in torrential beds. Three levels of uncertainty in procedure of CN determination could be minimized under the following circumstances:

- detailed classification of hydrologic soil groups in Serbia
- field investigation, mapping of surfaces and erosion processes in the studied catchment area, are indispensable measures before computation of maximal discharge Qmax .

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