A SCS-CN-BASED MODEL INCORPORATING DIRECT USE OF ANTECEDENT RAINFALL IN RUNOFF EQUATION

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Modeling of an event-based rainfall-runoff process is important in Hydrology. Soil Conservation Service Curve Number (SCS-CN) method is one of the widely used methods for computation of runoff from the given rainfall amount. Despite the fact that a number of modifications have already been suggested, there still exists a need for further improvement in the method for more accurate results. Hawkins (1978) stated some real and conceptual difficulties arising in applying this portion of NEH-4 procedures. First, the relationships are not continuous, thus implying sudden shifts in CN, with corresponding quantum jumps possible in calculated runoff. Secondly, NEH-4 contains no background development or statements of assumptions, leaving only appeals to agency authority as a foundation for professional beliefs, and not faith based on physical reasoning or reconciliation with reality. Ponce and Hawkins (1996) stated that the SCS-CN method employs mean values and therefore has room for variability. They attributed this variation to the spatial and temporal variability of rainfall, quality of measured rainfall-runoff data, and the variability of antecedent rainfall and the associated soil moisture amount. Literatures indicate that there is no clear definition of antecedent moisture which, of course, depends on antecedent rainfall. Though Mishra-Singh (2002) model, a recent version of the SCS-CN method, allows computation of antecedent moisture from the 5-days antecedent rainfall and then facilitates direct use of this in runoff equation, and thus avoids sudden jumps in CN, it does not clearly define antecedent moisture based on physical facts. It is based on the assumption that watershed is completely dry 5-days before onset of rainfall which is not reality.

Keeping above views, this study presents a SCS-CN-based modified model which allows direct use of 'antecedent rainfall' in the runoff equation and thus removes the ambiguous term 'antecedent moisture' from runoff computation process and then evaluates its impact. It covers the comparative performance evaluation of proposed model with SCS-CN method and MS model. The models used in the study are shown in Table-1.

Table 1. SCS-CN-Based Rainfall-Runoff Models under Present Study

Sl. No.	Methods/ Model Types	Model Formulations	λ
1	SCS-CN Method	$Q=\frac{(P-I_a)^2}{P-I_a+S}$	Varying
2		$I_a=\lambda S$	0.2
3	Mishra-Singh Model	$Q=\frac{(P-I_a)(P-I_a+M)}{P-I_a+M+S}$	Varying
4		$I_a=\lambda S$ $M=0.5[-(1+\lambda)S+\sqrt{(1-\lambda)^2 S^2+4P_5 S}]$	0.2
5	Proposed model	$Q=\frac{(P-I_a)(P-I_a+P_5)}{P-I_a+P_5+S}$ $I_a=\lambda S$	Varying
6			0.06
7			0.05

In an application to a large set of data from 84 small watersheds, varying in area from 0.17 to 71.99 ha, of U.S.A., the proposed modified model for varying λ has been found to perform better than any of the investigated seven versions of the SCS-CN-based models. This performance is based on two statistical criteria viz. root mean square error (RMSE) and normalized root mean square error (nRMSE). This model yielded the lowest values of mean RMSE (4.784 mm) and mean nRMSE (1.141). It advantageously obviates sudden jumps in the curve number with antecedent moisture condition which is an undesirable feature of the existing SCS-CN model.

Among the models with constant value of λ, special form of proposed model with λ = 0.05 performed the best, for it yielded lowest values of mean RMSE (4.828 mm) and mean nRMSE (1.162) among one-parameter models. This model with λ = 0.05 and direct use of antecedent 5-days rainfall (P_5) in the runoff-equation can be recommended as a better alternative to Model 2 for real world application.

Keywords: Antecedent rainfall, Antecedent moisture, Curve number

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