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Soil Conservation Service Curve Number Method & GIS Application for Surface Runoff Studies

Jakir Hussain K. N., Vijayakumari Raveendra Channavar, Varsha Somaraddi Radder and Jagadeesh B. R.

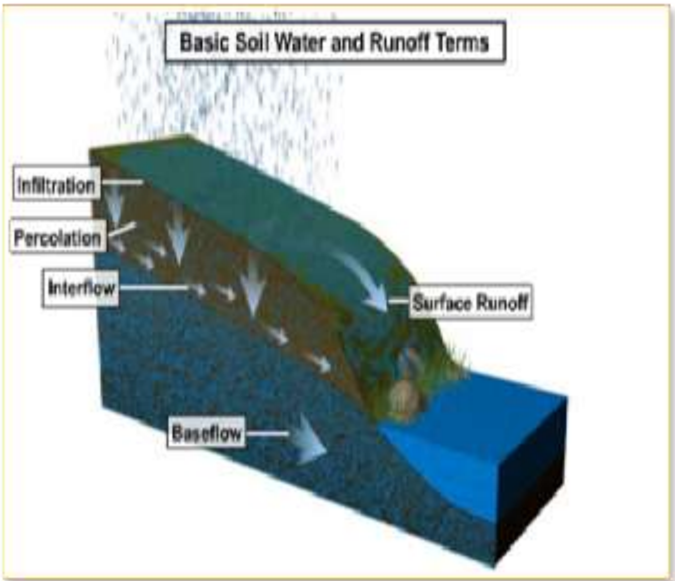
Department of Soil Science and Agricultural Chemistry, College of Agriculture, University of Agricultural Sciences, Dharwad

SUMMARY

The Soil Conservation Service Curve Number (SCS-CN) method, developed by the United States Department of Agriculture's Natural Resources Conservation Service, is a crucial tool in hydrology for assessing surface runoff potential in diverse landscapes. This empirical method considers factors such as land use, soil type, hydrological soil group, and antecedent moisture conditions to determine a curve number, reflecting a watershed's runoff potential. Widely applied in watershed planning, flood control, and water resource management, the SCS-CN method is enhanced by Geographic Information System (GIS) applications, which integrate spatial data on land cover, topography, and soil characteristics. This combination enables a comprehensive analysis of variables influencing runoff, providing a more accurate understanding of hydrological processes and supporting rapid decision-making in watershed management and conservation practices.

INTRODUCTION

The Soil Conservation Service Curve Number (SCS-CN) method, widely employed in hydrology, stands as a fundamental tool for assessing surface runoff potential in various landscapes. United States Department of Agriculture's Natural Resources Conservation Service developed this empirical method, which provides a systematic approach to estimate direct runoff from rainfall events. It considers factors such as land use, soil type, hydrological soil group and antecedent moisture conditions to derive a curve number that reflects a watershed's runoff potential. The SCS-CN method is particularly valuable for predicting runoff in different land management scenarios and extensively used for watershed planning, flood control and water resource management. In conjunction with SCS-CN method, Geographic Information System (GIS) applications enhance the precision and efficiency of surface runoff studies. GIS allows for the integration of spatial data related to land cover, topography and soil characteristics, enabling a comprehensive analysis tools influencing runoff within a specific geographical area. By utilizing GIS, researchers can develop model and interpret the complex interplay of variables affecting surface runoff contributing to a more accurate understanding of hydrological processes. The combination of the SCS-CN method with GIS applications constitutes a powerful approach to advance our knowledge of surface runoff dynamics and facilitates a rapid decision-making in watershed management and conservation practices.



- Surface runoff refers to the movement of water over the land surface, typically as a result of precipitation and vital role in understanding the movement of water across the Earth's surface and its interaction with the soil
- When precipitation occurs, the fate of water on the land is determined by the soil's physical and chemical properties
- Surface runoff occurs when the rate of rainfall or snowmelt exceeds the soil's infiltration capacity, leading to the flow of water over the soil surface
- Surface runoff is a fundamental component of the water cycle, influencing both natural landscapes and human activities
- Soil characteristics such as texture, structure, compaction, and permeability significantly influence the amount of water that can infiltrate into the soil and the portion that becomes surface runoff. Soils with high clay content or compacted layers are less permeable, resulting in increased surface runoff. Conversely, well-structured and permeable soils allow for greater infiltration, reducing the potential for runoff.

The characteristics of surface runoff are influenced by various factors, including the

Type of soil

- Land cover
- Slope of the terrain
- The intensity and duration of precipitation.

Type of soil

Land cover


Slope

Advance and rapidly expanding technologies such as Remote Sensing (RS) and Geographic Information System (GIS) hold a great promise to tackle the present challenges faced by Soil Scientists. The relation between rainfall and runoff volumes have been presented by many empirical and semi empirical formulae. Among the different runoff assessing methods, the USDA – Soil Conservation Service (SCS) curve number method is a well-accepted tool.

This method is also known as Curve Number-(CN) method. This is a simple, predictable and stable conceptual method

History of SCS-Curve Number

In 1933, the Soil Erosion Service (SES) was established in the United States. Then the Soil Conservation Act of 1935 came out, which changed the name of the agency to Soil Conservation Service (SCS). SCS realized that there was a need to obtain hydrologic data and to obtain a simple procedure for estimating rates of runoff.

With the passing of the **Flood Control Act of 1936** (Public Law 74-738), the Department of Agriculture was authorized to carry out surveys and investigations of watersheds to install measures for retarding runoff and water flow and preventing soil erosion

The Soil Conservation Service (SCS) Curve Number (CN) method is commonly used for estimating direct runoff or surface runoff in hydrology and watershed management. The method is particularly useful for predicting runoff from rainfall events in rural and undeveloped areas. The CN method involves assigning a curve number to a watershed based on land use, soil type, and hydrologic soil group.

The general equation for estimating direct runoff using the SCS CN method is:

It is assumed that the ratio of the direct runoff Q and the rainfall P minus the initial loss (P – 1a) is equal to the ratio of actual retention to the storage capacity, S.

$$\frac{Q}{P-1_a} = \frac{P-Q-1_a}{S}$$

The initial abstraction, 1a is assumed to be a fraction of S. On an average by taking 1a = 0.2 S the equation (1) becomes

$$\mathbf{Q} = \frac{(P-0.2S)^2}{P+0.8S}$$

Where:

Knowing P and S the value of Q can be computed. Q has the same units as P and is generally expressed in mm.

$$\mathbf{CN} = \frac{25400}{S} - 254$$

Where S is the recharge capacity of the watershed. Curve numbers for various groups are given by SCD,1972. These values apply to antecedent rainfall condition which is considered as an average condition. It's important to note that the SCS CN method provides an estimate of direct runoff, and the equations are empirical in nature. The curve number is determined based on the characteristics of the watershed, and it is a key parameter in these equations.

For GIS applications, spatial data such as land use, soil types, and hydrologic soil groups can be used to map the curve number across a watershed. GIS tools can help in the spatial analysis of these parameters and provide a more detailed and accurate representation of the watershed characteristics. The SCS CN method can then be applied to calculate direct runoff for different sub-areas within the watershed. Keep in mind that the specific implementation and data requirements for GIS applications may vary, and it's advisable to refer to relevant literature, guidelines, or software documentation for detailed instructions.

CONCLUSION

The integration of the Soil Conservation Service Curve Number (SCS-CN) method with Geographic Information System (GIS) for surface runoff studies enhances precision in estimating runoff potential. This combined approach, considering factors like land use and soil properties, allows for a comprehensive understanding of watershed dynamics. The synergy between the SCS-CN method and GIS facilitates accurate modeling and support rapid decision-making in water resource management, land use planning and conservation practices. This tandem application proves to be a valuable tool for addressing the complexities of surface runoff in diverse geographical settings.

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