ABSTRACT

Watershed has long been identified as the most rational unit for planning and implementation of the programmes to enhance agricultural production as well as all-round development of mankind. The main aim of watershed planning and management is to use the two most important natural resources, viz. land and water. The potential of food production of a country is assessed from the availability of land and water resources, both in quantitative as well as qualitative terms. Improper or ineffective utilization of these natural resources leads to diminishing crop production, land degradation and hazards like drought and flood, ground water contamination etc. This also causes hardship to human beings for domestic, municipal and industrial use of water. Consequently, watershed management has become the cornerstone of planning and development of land and water resources of our country. This calls for a clear understanding of hydrological processes of which infiltration is a major component influencing the water balance of the watershed. Infiltration is defined as the entry of water from the surface into the soil profile. It is the infiltration capacity of a soil that determines for a given storm, the amount and time distribution of rainfall excess that is available for runoff and surface storage. An understanding of infiltration and the factors affecting it is important to the determination of surface runoff as well as subsequent movement and storage of water within the watershed. Though, infiltration may involve soil water movement in two or three dimensions, it is often treated as one-dimensional vertical flow. Attempt to characterize infiltration for field applications have usually involved simplified concepts permitting infiltration rate and cumulative infiltration expressed algebraically in terms of time and certain soil parameters.
Infiltration into homogeneous soils with flat stable surfaces is well understood, and can be satisfactorily modelled on a wide variety of soil types. However, the infiltration behaviour of soils with disturbed surfaces and non-homogeneous layers is poorly understood. Few attempts at modelling this behaviour have been made, but appropriate knowledge of the effects of infiltration is essential for effective management practices to be carried out on these soils. Land areas subjected to tillage and fertilizer applied cultivation and mine reclamation; as well as, bare crusted soils are some examples of situations where this type of information is essential. In this study, two separate models were developed to estimate infiltration under different boundary and soil-matrix conditions. One model using physically based Green and Ampt equation can be applied as a lumped model on two different soil layers under rainfall conditions. Another is distributed model, where implicit method of finite difference discretization scheme was applied to one-dimensional form of the Richards equation. Both the models were superimposed by a transient surface crust model. The surface crusting parameters can be evaluated by a simple iterative process using observed infiltration data obtained from double-ring infiltrometer experiments. Two types of fertilizers, viz. one organic manure and another chemical fertilizer, were applied in the top 30 cm of the soil (considered to be the plough layer) to see the effect of fertilizer application and soil heterogeneity. Capillary rise experiments and horizontal infiltration experiments were conducted in the laboratory to generate soil-moisture characteristic data which were fed to an available computer programme RETC using van Genuchtan soil-moisture retention model. The output from this programme was used as input to the infiltration models.
Infiltration characteristics observed during field experiments were compared with the results of simulations of both the physically based and numerically based models to check their applicability. Though the performance can be visually interpreted by plotting the simulated and observed infiltration rates and cumulative infiltration volumes, statistical tests were evaluated to give some quantitative performance of the models. In this study, the performance of the developed models was investigated using different statistical parameters, viz. modelling efficiency, coefficient of residual mass and coefficient of variation. Infiltration rate and cumulative infiltration were well predicted by both the models. Very good agreement between observed and predicted infiltration rates could be obtained by taking surface crusting into account. The parametric values describing the surface crusts were calculated from observed infiltration data. The average values of these parameters were calculated for each experimental setting by moving the observed time and cumulative infiltration data point. These average values were then used as inputs to the surface crusting model for that given experimental setting. However, surface crust parameters were found to vary considerably depending on the data set used to obtain the crust parameters. Initial crust conductivity was found to be widely variable in all the cases considered. A change in parametric values with time may be attempted for this purpose.

The results of sensitivity analysis indicates that time to ponding was very sensitive to rainfall intensity, whereas, cumulative infiltration was not very sensitive to rainfall intensity, the effect becoming negligible as rainfall intensity increased. Time to ponding was found to be more sensitive to rainfall intensity when no surface crusting was developed. Surface crusting reduced the effect of rainfall intensity. Cumulative
infiltration was very sensitive to final crust conductivity and least sensitive to decay constant and initial crust conductivity. Cumulative infiltration was found to be very sensitive to antecedent moisture content and average suction at the wetting front.