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The Role of Soil Pipes and Pipeflow in Headcut Migration Processes

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Headcut formation and migration is sometimes mistaken as the result of overland flow without realizing that the headcut was formed by or significantly influenced by flow through soil pipes into the headcut. To determine the effects of a soil pipe and flow through a soil pipe on headcut migration, laboratory experiments were conducted under free-drainage conditions and conditions of a shallow water table. Soil beds with a 3-cm deep initial headcut were formed in a flume with a 1.5-cm diameter soil pipe 15 cm below the bed surface. Overland flow and flow into the soil pipe was applied at a constant rate of 68 L/min and 1 L/min, respectively, at the upper end of the flume. The headcut migration rate and sediment concentrations in both surface (channel) and subsurface (soil pipe) flows were measured with time. The typical response without a soil pipe was the formation of a headcut that extended in depth until an equilibrium scour hole was established at which time the headcut migrated upslope. The presence of a soil pipe below the channel, and particularly the phenomena of flow through a soil pipe and into the headcut, whether by seepage from a shallow water table or upslope inflow, significantly impacted the headcut migration. Pipeflow caused erosion inside of the soil pipe at the same time that runoff was causing a scour hole to deepen and migrate. When the headcut extended to the depth of the soil pipe, surface runoff entering the scour hole interacted with flow from the soil pipe also entering the scour hole. This interaction dramatically altered the headcut processes, greatly accelerated the headcut migration rates and sediment concentrations. Conditions in which a perched water table provided seepage into the soil pipe in addition to pipeflow increased the sediment concentration by 42% and the headcut migration rate by 47% compared with pipeflow under free-drainage conditions. The time that overland flow converged with subsurface flow was advanced under seepage conditions by 2.3 and 5.0 minutes compared with free-drainage condition. This study confirmed that pipeflow dramatically accelerates headcut migration especially under conditions of shallow perched water tables and highlights the importance of understanding these processes in headcut migration processes.