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Soil indicators of hillslope hydrology

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Abstract

Water is the main agent in the weathering of rocks and the formation of soils. Water driven processes of soil formation leave signatures of flowpaths, storage mechanisms and residence times. The topography and vadose zone characteristics (impermeable soil layers, fractured rock patterns and rock layers) manipulate the distribution of water in the landscape resulting in a variation in water related soil features. This interactive relationship between soil and hydrology provides the foundation of soil distribution patterns associated with soil/terrain data bases like the Land Types of South Africa. This makes it possible to conceptualise the hydrological behaviour of hillslopes and ultimately of catchments. It is also essential that these aspects be efficiently captured in hydrological models for accurate water resources prediction, estimating the hydrologic sensitivity of the land to cultivation, contamination and development, and for quantifying low flow mechanisms. In the Weatherley catchment in South Africa neutron water meter measurements confirmed the interpretation of the soil water regime of the soil horizons of representative hillslopes. A first approximation of the hydropedology of South African soil types was developed from the duration of drainable water in different soil horizons. In a hillslope, underlain by horizontal layers of sedimentary rock, a time lag was found to occur between a rain event and changes in redox conditions of the E and G horizons of a down slope A/E/G soil profile. The inability to relate rainfall events to redox conditions in the E horizon could be attributed to water entering the E and G horizons through different routes, namely laterally through interflow generated by upland soils for the E, and through the layered rock of the hillslope for the G horizon. It is postulated that the non-abrupt E/G transition is an indication of the dominant role of the phreatic water table, with a large component of upward water movement into the E horizon. With this background a conceptual hydropedological model was developed using soil morphology and evaluated using hydrometric measurements in the form of tensiometers and streamflow hydrographs. The hydropedological model predicted streamflow well for the Weatherley catchment emphasizing the role of soil in hydrology and the importance of soil in hydrological models. Soil properties serving as indicators of hillslope hydrology are often observed and recorded in soil surveys. Detailed hydropedological interpretation has, however, in the past tended to be neglected. Soil surveys of dominant hillslopes can improve the development of conceptual models and hydrological modelling in ungauged basins.