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Development of a transient-ephemeral shallow aquifer in a sandy hillslope: Its role on phosphorus transport

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Fertilizer application and grazing enterprises on sandy soils constitute a common feature of several catchments contributing to RAMSAR-listed wetlands in the Peel-Harvey area near Perth, Western Australia (WA) where phosphorus (P) losses have become a concern due to the poor retention ability of these soils. Lack of information at the adequate scales limited the use of numerical models to assess water and P subsurface pathways in the area. New eco-hydrological approaches at the hillslope scale have provided a framework to unlock key first-order control processes in nutrient cycling and transport by simultaneously monitoring water movement and nutrient process from uplands down to riparian zones.

The present study specifically focuses on the hydrometric data analysis for the shallow-ephemeral groundwater table and uses surrogate electrical conductivity data (EC) and P concentration data to elucidate hydrological processes and the transport and fate of P across the hillslope. An experimental hillslope in the Mayfield drain catchment (Harvey river, WA) was instrumented with two transects of eight shallow wells from upland down to riparian zones. Groundwater table level was continuously monitored to determine its development in each landscape zone, lateral hydrological connectivity (HC), response to rainfall and surface inundation, and role on P transport. The study period covered one wetting and drying hydrological cycle (April-November 2011) enabling the identification of the basic dynamics associated with recharge and lateral subsurface flows.

Clear spatial and temporal differences in the water levels dynamics of the water table across the landscape resulted from differences on the soil storage capacities, catenary controls, and recharge mechanisms prior the occurrence of the lateral water movement via the subsurface HC. At the onset of the wet season, hydrometric data and EC values indicated that rapid vertical infiltration of rainfall water in the upland soils (92 % sand up to a depth of 2.5 m) and infiltration from surface water ponding at the midslope location (50% sand at the top soil layer) constituted the main recharge mechanisms for the upland and the midslope areas respectively. A localized surface recharge from an adjacent drain to the riparian zone location took place during the occurrence of a large rainfall event. Lateral HC between upland and midslope locations was achieved in the middle of the wet season after a total of 350 mm of rain, as water levels reached a high conductivity soil layer. An extra 60 mm of rainfall was required to achieve fully connectivity across the hillslope with the groundwater table surfacing at the riparian zones. Temporal and spatial patterns of total P concentrations in the groundwater reflected the water table dynamics and corroborated its initial transport from upland to midslope, the initial P retention capacity of riparian zones soils and the apparent later P release from these areas. The conceptual hydrodynamic and P transport model obtained at this early phase of the research constitutes an important step for hypothesis testing and processes identification on the mechanisms of groundwater recharge and P transport for the area via 2D numerical modelling exercises.