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Short Communication

Hydropedological grouping of South African soil forms

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The science of hydropedology has progressed significantly in the past two decades, especially with regards to the interpretation of soil morphology and relating these interpretations to the hydrological behaviour of horizons, profiles, hillslopes and catchments. Soil classification is pivotal to hydropedological interpretation and several studies have attempted to relate soil forms (as in the South African soil classification) to hydropedological behaviour. Here we present a cohesive grouping of the soil forms into four main hydropedological types, namely recharge, interflow, responsive and stagnating soils. This grouping will improve the efficiency of hydropedological assessments of soils, hillslopes and catchments for hydrological and ecological purposes.

Keywords: hydrology, morphological properties, pedology, soil classification

Water plays a primary role in the formation of morphological properties of soils, and soils act as a first-order control on hydrological processes through portioning of water flowpaths, which govern residences times of water in hillslopes. This interactive relationship between soil and water forms the basis of hydropedology, a relatively new research field that aims to bridge gaps and scales between pedology, soil physics, hydrology and geomorphology (Lin 2003). Hydropedological studies therefore emphasise that soils both control hydrological processes (through their hydraulic properties) and serve as indicators of hydrological behaviour (through interpretation of morphological properties).

In the past 15 years, significant progress has been made in South Africa towards the understanding, conceptualisation and quantification of hydropedological processes. The focus was mainly on interpretation of soil morphology in relation to hydropedological behaviour at different scales: soil horizons (e.g. van Huyssteen et al. 2005), profiles (e.g. van Tol et al. 2013a; Bouwer et al. 2015; Le Roux et al. 2015), hillslopes (e.g. Kuenene et al. 2011; van der Waals 2013; van Tol et al. 2013b) and catchments (e.g. van Zijl et al. 2016; van Tol and Lorentz 2018). These interpretations (and the science of hydropedology) were readily adopted by researchers and consultants in the environmental sector. Hydropedological studies have assisted in the configuration and parameterisation of hydrological modelling, identification of pollution migration pathways, identification of wetland sources and determination of appropriate wetland restoration mechanisms. A hydropedological report has also become a prerequisite for application of a water use licence (WULA) in open-cast mining or when similar drastic land-use change is envisioned.

Pivotal in most of the hydropedological studies was the interpretation of existing soil information. This relies on the hydrological interpretation of the classification of soils in accordance to the South African soil classification system (Soil Classification Working Group 1991). Many of the previously mentioned studies interpreted the classified soils and related it to their hydropedological behaviour; four hydropedological soil types were identified and they are briefly discussed below.

Recharge soils

Soils without any morphological indication of saturation. Vertical flow through and out of the profile into the underlying bedrock is the dominant flow direction. These soils can either be shallow on fractured rock with a limited contribution to evapotranspiration or deep freely drained soils that can contribute significantly to evapotranspiration.

Interflow soils

Two types of interflow soils occur, those where interflow is dominant at the A/B horizon interface and those where interflow is dominant at the soil/bedrock interface. The first type occur in duplex soils where the textural discontinuity facilitates build-up of water in the topsoil. In the second, freely drained soils overlie relatively impermeable bedrock. Hydromorphic properties signify periodic saturation associated with a water table at the soil bedrock/interface. The duration and magnitude of lateral flow in interflow soils depend on the rate of evapotranspiration, position in the hillslope (lateral addition/release), slope angle and the

Table 1: Hydropedological grouping of South African soil forms

Recharge		Interflow		Responsive		Stagnating
Deep	Shallow	A/B horizon	Soil/bedrock	Shallow*	Saturated	
Kranskop	Nomanci#	Kroonstad	Lamotte	Nomanci€	Champagne	Steendal
Magwa	Mayo#	Longlands	Fernwood	Arcadia	Rensburg	Immerpan
Inanda	Milkwood#	Wasbank	Westleigh	Mayo€	Willowbrook	Dresden
Lusiki	Jonkersberg	Klapmuts	Avalon	Milkwood	Katspruit	Glencoe
Sweetwater	Glenrosa#	Villafontes	Pinedene	Glenrosa€		Molopo
Bonheim	Mispah#	Kinkelbos	Bainsvlei	Mispah€		Askham
Inhoek	Witbank	Cartref	Bloemdal			Kimberley
Constantia			Witfontein			Plooysburg
Tsitsikamma			Sepane			Garries
Concordia			Tukulu			Etosha
Houwhoek			Montagu			Gamoep
Griffin						Oudtshoorn
Clovelly						Addo
Hutton						Prieska
Shortlands						Trawal
Pinegrove						Augrabies
Groenkop						Brandvlei
Valsrivier						Coega
Swartland						Knersvlakte
Dundee						
Namib						

* Includes soils with very low infiltration rates

\# Soils overlying fractured bedrock (e.g. soil families with lithocutanic B horizons that are 'not hard' and soil families where A horizons are 'not bleached')

€ Soils overlying relatively impermeable bedrock (e.g. soil families where lithocutanic B horizons are 'hard' and soil families with bleached A horizon

anisotropy in permeability between the conducting and impeding layer.

Responsive soils

These soils 'respond' quickly to rain events and typically generate overland flow. These soils can be shallow and overlie relatively impermeable bedrock, with limited storage capacity that is quickly exceeded following a rain event. Alternatively, they are soils with morphological indications of long periods of saturation. Given that the latter soils are close to saturation during the rainy season, additional precipitation will typically flow overland due to saturation excess.

Stagnating soils

In these soils outflow of water is limited or restricted. The A and/or B horizons are permeable but morphological indicators suggest that recharge and interflow are not dominant. These includes soils with carbonate accumulations in the subsoil, accumulation and cementation by silica, and precipitation of iron as concretions and layers. These soils are frequently observed in climate regions with a very high evapotranspiration demand. Although infiltration occurs readily, the dominant hydrological flowpath in the soil is upward, driven by evapotranspiration.

The link between soil forms and their hydropedological type has been established in several hydropedological studies (e.g. Le Roux et al. 2015; van Tol and Lorentz 2018). This was, however, reported on a case-by-case basis. With this in mind, it is timeous to present a unified and tested hydropedological concept grouping as applied to the soil forms of the South African soil classification system (Table 1).

Table 1 provides the basis for hydropedological grouping of soil profiles. In order to understand, conceptualise and quantify the hydropedological behaviour of landscapes, it is important that other aspects are also included in hydropedological assessments. This includes *inter alia* the coverage and sequence of different hydropedological soil types in the landscape, hydraulic properties of the soils (e.g. texture and hydraulic conductivity) and the climate of the specific area. This hydropedological grouping of soil forms will improve the development of conceptual hydrological response models for hillslopes (van Tol et al. 2013b). These models can be applied in land-use change assessments, wetland preservation studies, configuration of hydrological models and any other study where dominant flow processes must be understood.

Geolocation information

South Africa: 22°–35° S; 16°–33° E.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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