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TECHNICAL BRIEF

Hydrology

Hydrology of SA soils and hillslopes

A completed Water Research Commission (WRC) study developed techniques which allow the dominant soil and hill-slope runoff generating mechanisms to be used in catchment scale runoff simulation.

Background

This WRC project aimed to develop a hydrologically based classification system of SA soils and hillslopes.

The hydrology of SA soils and hillslopes (HOSASH) aims to assist in hydrological modelling especially in ungauged basins. The project further aimed to develop techniques suitable for studying the hydrology of SA soils and hillslopes.

This includes an improved understanding of soil water regime, permeability and near saturation water flow in all directions; distribution and role of characteristic hillslopes of South Africa and the possible impact of a hydrological classification of soils and hillslopes on hydrological modelling.

The project aimed to develop, test and calibrate HOSASH in a variety of environments in South Africa, with the best available hydropedological, climate, geohydrological and hillslope data.

The aim includes the application Digital Soil Mapping that can help predict the response of the hillslopes of a catchment. The project aimed to transform Land Type data (based on soil distribution patterns in hillslopes) and available soil data at all scales of soil survey (from intensive to reconnaissance) into hydropedological data that can be useful for ecohydrology, hydrology and especially for hydrological prediction in ungauged basins.

Results Hydropedology contributes to hydrology in improving conceptual hydrological response models for South African hillslopes and improved parameters for: the hydrological components of soils, namely individual soil properties; soil horizons as combinations of soil properties; soil types as combinations of soil horizons; and soil distribution patterns, as topographical combinations of soil types.

Soil morphology, applied in soil classification, is now an established indicator of flowpaths and storage mechanisms of water in hillslopes. Hydrological soil properties of a variety of soil horizons and soil types were quantified paving the way to populate the national soil data base (Land Type data base) with hydrological data linked to soil horizons, soil types and soil distribution patterns.

Main results

The project has demonstrated that in cooperation with process hydrology we have, for any catchment in South Africa, generated the knowledge, skills and tools to:

- Improve conceptual hydrological response models for hillslopes using soil properties, soil horizons, soil types and the distribution of these in hillslopes as indicators and controls of flowpaths and storage mechanisms in the vadose zone;
- Identify the most important hydrological hillslopes of small catchments (large scale) by hydropedological soil surveys;
- Identify the most important hydrological hillslopes of large catchments (small scale) using Land Type Survey data;
- Measure what happens in a hydrological hillslope, including the upper and intermediate vadose zone, during rainfall events of different intensities;
- To simulate, using virtual experimentation based on a scientifically sound mechanistic flow model applying realistic soil parameters, a reasonably reliable representation of

what actually happens in a hillslope during a rainfall event;
- Use these results on a continuous basis, implementing PTF's (pedotransfer functions), STFs (soil transfer functions) and HiTF's (hillslope transfer functions), and together with the improved South African soil classification system, to improve the understanding and modelling of HOSASH;
- Close the gap between experimentation and modelling by improved application of soil data, including hydropedological classification of soils and hillslopes on all scales;
- Develop modular/characteristic hydrological response models for soil components at all scales, namely horizons, soil types, hillslopes and Land Types suitable for prediction of one, two and three dimensional hydrological responses in soil bodies and hillslopes.

Equipping the team to reach this level of skills required that several barriers had to be challenged. Pedology, the science of understanding the different types of soils, creates the possibility to predict their responses to different treatments. It started in natural science but food security driven by World Wars I and II and the Cold War, focused pedology on crop production.

Awareness of global health and water shortage broadened the application to serve hydrology. Pedology benefits hydrological modelling, especially in unguaged catchments, and it will also contribute to mitigating the impact of economic development on hydrological responses and ecohydrology.

As morphological soil properties react slowly to a changing environment, the current validity of their relationship with hydrology has been questioned. The first breakthrough was that ancient, easily observable morphological soil properties used to classify soils, are well correlated with the long-term average duration of drainable water in soils. This laid the foundation for the hydrological classification of soil horizons and types.

Soil chemical reactions and the associated soil chemical properties, precede soil morphological changes, are therefore hydrologically more sensitive parameters indicating more specific hydrological responses.

A good correlation between soil morphology and soil chemical properties has been confirmed. The response of soil horizons, soil types and soil distribution patterns has been strengthened using natural isotope studies and hydrometry as current indicators of soil and hillslope hydrological responses.

Quantification of the contribution of soil horizons and soil types to the recession curve of the hydrograph narrowed the gap between soil data and hydrological models.

On large scale the distribution of soils can therefore be classified hydrologically and used to develop conceptual hydrological response units for catchments. On small scale Land Types can be disaggregated to hydrological hillslopes as hydrological response units. Integrated soil data were used in much more detail, both as indicator and controller of hydrological response of hillslopes, to predict hydrological response using a model.

Further reading:
To order the report, *HOSASH (Hydrology of South African Soils and Hillslopes)* (**Report No. 2021/1/15**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.