Modelling of water infiltration and soil swelling in a vertisol from Guadeloupe

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WATER FLOW AND SOIL WATER CONTENT VARIABILITY IN GRASS-COVERED HEAVY CLAY AND PEAT SOILS OF THE NETHERLANDS

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In the Netherlands many grass-covered heavy clay and peat soils are susceptible to drought and difficult to wet after a dry period. A major proportion of precipitation can flow rapidly through shrinkage cracks towards the subsoil, bypassing the matrix of the soils. However, trenches studied in these soils revealed that preferential flow is not limited to macropore flow: irregular and fingerlike wetting patterns are also formed through the small pores of the matrix. The diameter of the patterns exceeded the width of individual cracks, indicating that the surrounding matrix was participating in the vertically directed flow as well. These preferred pathways are thought to form at places with cracks which receive relatively large amounts of water, due to water moving over the surface and through the surface layer towards slightly lower places. Hence, the surrounding small pores in the matrix can be wetted as well, resulting in irregular wetting patterns. As a consequence of these patterns, variability in soil mois-ture content is high. We found large differences in soil moisture content in the heavy clay and peat soils in all layers sampled at all the sites and for all measurements. Large differences in wettability exist between wet and dry soils, due to water repellency being induced at low water contents. Resistance to wetting was determined by measuring the wetting rate of field-moist samples with varying water contents.

MODELLING OF WATER INFILTRATION AND SOIL SWELLING IN A VERTISOL FROM GUADELOUPE.

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Models of water infiltration in undisturbed swelling soils rely on a dual porosity concept: Darcy flow in the micro (matric) porosity and by-pass flow in cracks. In vertisols from the humid tropics, a third component must be added: the structural porosity, excluding cracks, formed by the soil microfauna activity and containing water easily available for plants. A model was implemented to study the mecanisms of water infiltration: (i) water infiltration in the matric porosity is modelled by the Darcy law, (ii) the flow in the structural porosity is a gravity-dominated flow, (iii) water entering cracks is instantaneously added at the bottom of the cracks. Water movement from structural to matric porosity and from crack's wall into soil matrix are accounted for. Cracks opening is a function of soil matrix moisture. Shrinkage curve, retention curve and hydraulic conductivity of the matrix were measured in the laboratory. The anisotropy ratio of soil deformation was measured *in situ*. Experiments were conducted *in situ* to fit some soil structure parameters and test the model. Although not wholly validated because of a poor modelling of infiltration in structural porosity, the model already shows that infiltration in this soil is a 3D process and that water infiltration in structural porosity is the main factor of rainfall partition between vertical infiltration in the soil matrix and water flow into the cracks. Therefore, new researches should focus on water flow in structural porosity.

INFILTRATION OF WATER INTO SOIL WITH CRACKS: MODEL DESCRIPTION AND RESULTS OF MODELING.

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Results of modeling of precipitation water infiltration into soil with cracks are presented, as well as short description of the model FRACTURE which is a part of the SPAC model HYDRUS - ET, developed previously by joint effort of the U.S. Salinity Laboratory and by the Institute of Hydrology Slovak Academy of Sciences. The model FRACTURE is based on the two simultaneously running infiltration processes: infiltration into soil through soil surface calculated by the Richards equation and filling up of soil cracks and following infiltration of this water horizontally into soil matrix, using Green - Ampt approach. This process is involved in Richards equation as a source term. To quantify cracks infiltration two additional information are needed: so called *shrinkage curve*, which is the relation between crack porosity and soil water content and *specific length of soil cracks* on the soil surface. The next task is in improving of the model application will be parametrization of the cracked soils properties (specific cracks length l_c and relationship $P_c = f(w)$) needed as input data to the model FRACTURE, thus making possible routine modelling of infiltration into cracked soils.

SIMULATION MODELLING OF VARIABLE SOIL WATER RESPONSES TO RAINFALL IN A CRACKING CLAY SOIL, BRIMSTONE FARM, UK.

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This paper will make use of an extended data-set comprising readings of soil water tension from an area of 9m^2 which has been instrumented with 4 nests of 3 tensiometers for an 18 month period at Brimstone Farm, near Faringdon in the UK. The tensiometers have been connected with a Scanivalve fluid switch, and read sequentially every 2.5 minutes over a 45 minute interval. Supplementary data include soil moisture readings from a Neutron Moisture Probe, precipitation, net radiation, temperature and relative humidity. The soil at this site is a cracking clay characterised by the seasonal development of shrinkage cracks which inhibit any generalisation of soil water flow. A summary of field-work result will be provided, which clearly indicate the influence of macropores in determining soil water response to rainfall of varying magnitude. The way in which theses data are able to direct the development of a process-response model for specific tensiometer nests will be described, and their general applicability will be

MANAGEMENT OF SOIL WATER IN TEMPERATE CLAY SOILS: MOLE DRAINAGE AND THE ROLE OF STRUCTURE.

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Clay soils in temperate environments present difficulties in mangement, although rewarded by high agricultural yields. Artificial drainage is essential for the successful cultivation of such soils. In the UK this is most commonly achieved by the use of mole drainage, which has the effect of both improving the structure and providing an unlined drainage channel in the soil. However, the successful drainage of soils also leads to the prospect of rapid leaching of pollutants.
This paper will review experience in the experimental techniques required to study the hydrology and water quality of such soils; and the development of models to predict the leaching of pesticides and nitrates from these soils.

DERIVING PARAMETERS FOR THE DETERMINATION OF MACROPORE FLOW IN CLAY SOIL

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Field investigations carried out in Sjökulla Experimental Station located south of Finland have shown that only the macropore flow of the soil is significant due to the extremely low permeability of clay soil. Field experiment was carried out to investigate the geometrical configuration of the macropores using the dye agent Brilliant Blue ($C_{47}H_{48}N_3O_7S_2Na$) as a tracer to map the macropores. Evidences gathered have shown that water entrapment in cracks may reach up to 70% of the total rainfall. That amount of water losses depends mainly upon the dryness of the topsoil which initiates the opening of the "crack's mouth". A method for calculating the macropore flow in clay soil has been developed. Drain flow records, surface runoff, evapotranspiration and rainfall measurements over a considerable period of time have been used to construct the model. Physical characteristics of the catchment were lumped in one parameter called a retardation factor (κ). In addition, another parameter (Γ) was used to describe water entrapment in cracks and other macropores. These two parameters were both described as a function of rainfall and incorporated in a mathematical model that describes soil continuum as a vertical cylinder. Conventional models, which do not consider water entrapments in cracks, may overestimate water discharge from the catchment and ultimately overestimate pollution impact on rivers and lakes. In light of the testing results, the model can serve as a useful tool for calculating water and solute balance in agricultural clay soil. However, further field investigations are still being carried out to establish a better parameterization to the water losses in discontinuous cracks.