HYDROLOGY OF A SOUTHEASTERN COASTAL PLAIN PLINTHIC SOILSCAPE

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Abstract

The National Cooperative Soil Survey (NCSS) is nearing completion of soil inventories and is now emphasizing landscape scale map unit ("soilscape") interpretations. Interpretations associated with soil hydraulic properties are of particular importance. Soils with plinthite (plinthic soils) constitute appreciable acreage of the Southeastern US Coastal Plain. Plinthite is a soil hydromorphological feature; however, its effects on soil hydraulic properties are not well understood. Therefore, a study was initiated in the Alabama Coastal Plain on a plinthic soil catena [Plinthic Kandi- and Paleudults] (objectives listed below). A transect was established consisting of three nests of instrumentation (piezometers, wells, soil water content) for monitoring both unsaturated and saturated conditions. Plinthite quantities along the catena ranged from <1 to 42% plinthite in subsoil horizons. Significant correlation (α=0.05) between soil hydromorphic features, plinthite and contemporary saturation was observed. Minimum NCSS saturated hydraulic conductivity (K_{sat}) estimates were significantly higher than measured values (p-value = <0.001). Nine of 17 measured horizons had K_{sat}'s in lower NASIS K_{sat} classes than NCSS minimum estimates. HYDRUS-1D simulations were somewhat effective for predicting saturation (RMSE =70-cm pressure). Water retention curve derived hydraulic parameters reduced HYDRUS-1D simulation RMSE an average of 49% over Rosetta estimated parameters.

Introduction

Plinthite, an Fe-rich, humus-poor mixture of clay with quartz and other minerals, is a hydromorphological feature common to Southeastern Coastal Plain soils. Plinthite has been reported to restrict vertical water movement and initiate perching and lateral flow, as well as to be indicative of both perched and apparent water tables. However, the relationship between plinthite and contemporary seasonal saturation is unclear. As this uncertainty remains and with limited data characterizing the hydraulic properties of plinthic soils, studies evaluating soil water dynamics across plinthic soilscapes will improve interpretation and management of the over 4 million acres of Plinthic soils in Alabama and Georgia. Our objectives are to **1)** develop improved relationships between soil hydraulic properties and plinthite occurrence, quantity and morphology, **2)** Compare measured soil hydraulic properties with NCSS estimates and **3)** evaluate the validity of HYDRUS 1D simulations in plinthic soilscapes.

Materials And Methods

Site Location and Characterization

- 4.5-ha catchment on AAES's Gulf Coast Research & Extension Center
  - Fairhope, Baldwin Co., AL **(Fig. 1)**
  - Citronelle Formation of AL Coastal Plain
- Management: seasonally grazed bahiagrass pasture
- Site characterization: RTK-GPS DEM & Order 1 soil survey
- Soils: Fine-loamy, kaolinitic, thermic Plinthic Kandiudults (Upland to lower backslope) & Fine, kaolinitic, thermic Plinthic Paleaquults (Grady pond)
  - 0-42% plinthite in subsoil; <5% ironstone in upper solum

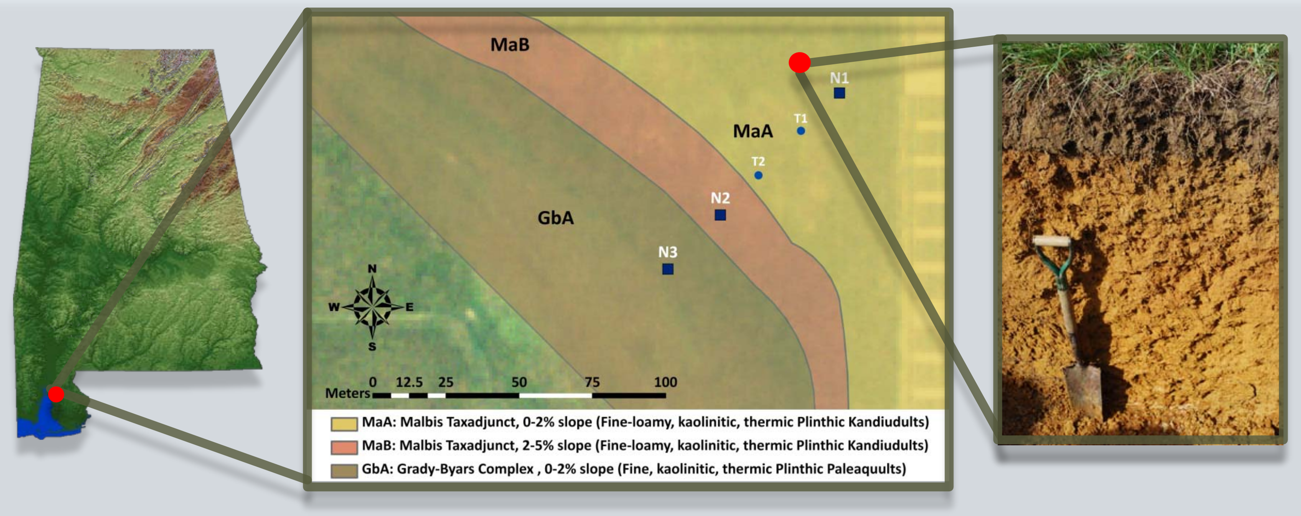

Fig. 1. Research site on 4.5-ha catchment in Fairhope, AL. Order 1 soil survey with instrumentation transect & a sampled upland Plinthic Kandiudult (N1) profile shown.

Field Instrumentation

- Transect with three instrument nests (N1, N2, N3):
  - nested piezometers (3),
  - monitoring well (1) and
  - soil water content sensors (3).
- 1hr monitoring interval for 17 month period **(Fig. 2)**

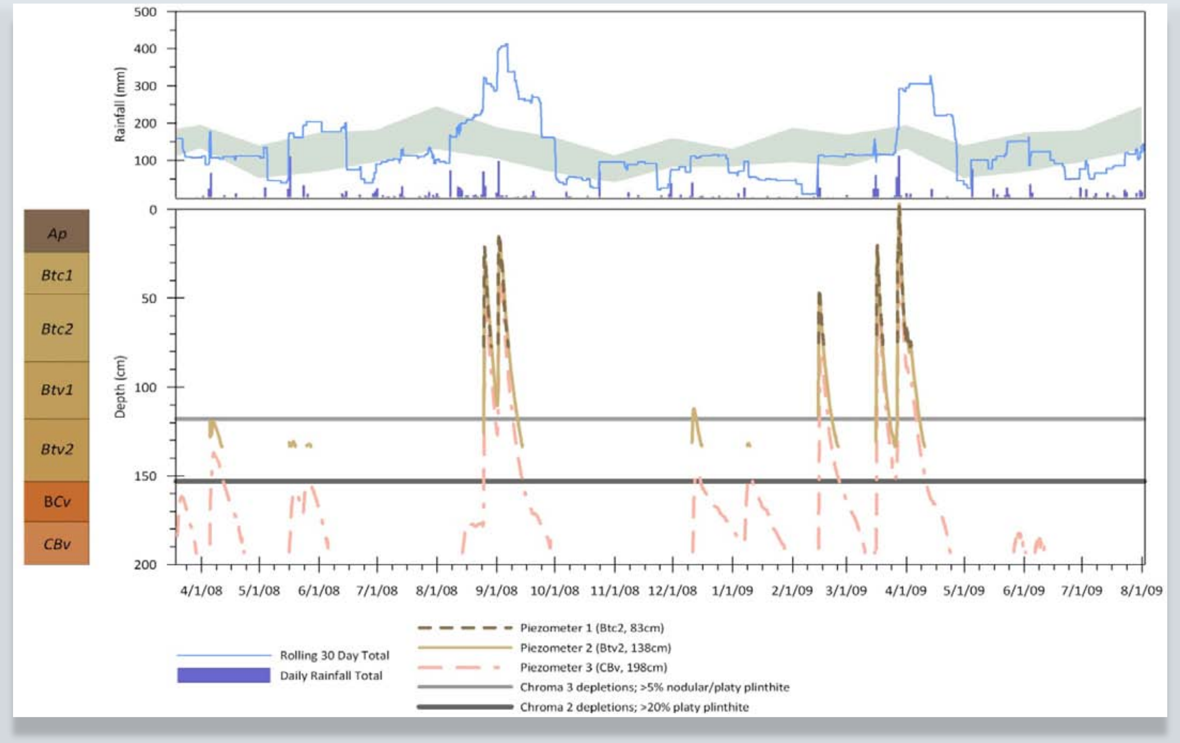

Fig. 2. N1 rainfall and depth to saturation.

Measurements

- Pedons described, sampled & characterized by NCSS standard methods
- Plinthite quantified by slaking procedure (Kelly, 2007)
- In-situ K_{sat} measurements with compact constant-head permeameter
- Water retention curves (WRC) measured using Tempe cells & pressure plates

Simulation Modeling

- van Genuchten parameters q_r, α and n fitted using WRC data in RETC; also, estimated in Rosetta Lite using:
  - Lab texture data and NCSS estimated ρ_b, ⅓ & 15 bar water content
- HYDRUS-1D: Mechanistic; numerically solves the Richard's equation
  - Five (5) 20 day simulations for both N1 and N2
  - Comparisons with field observations at 10 & 20 days

Results and Discussion

- Presence and quantity of redoximorphic features corresponded well with contemporary saturation **(Table 1)**
- % plinthite related to % time (PTS), longest duration (LDS) and >21 day periods (NPS) of saturation (p-value <0.001)

Table 1. Saturation metrics for horizons (n) in N1 and N2 with hydromorphic features. PTS and NPS normalized for 365 day year.

Hydromorphic Feature(s)	n	PTS	LDS	NPS
Few Plinthite Nodules	5	4.4	7.7	0.0
Soft Fe Acc.	5	5.8	9.2	0.0
Common Plinthite	3	14.8	20.2	0.6
Chroma 3 depletions & Soft Fe Acc.	2	17.7	25.3	0.8
Chroma ≤2 depletions	5	52.4	67.9	2.9
≥20% Platy Plinthite	4	54.3	76.1	3.2

- K_{sat} in 9 of 17 measured horizons in lower NASIS K_{sat} classes than NCSS minimum estimates **(Fig. 3)**

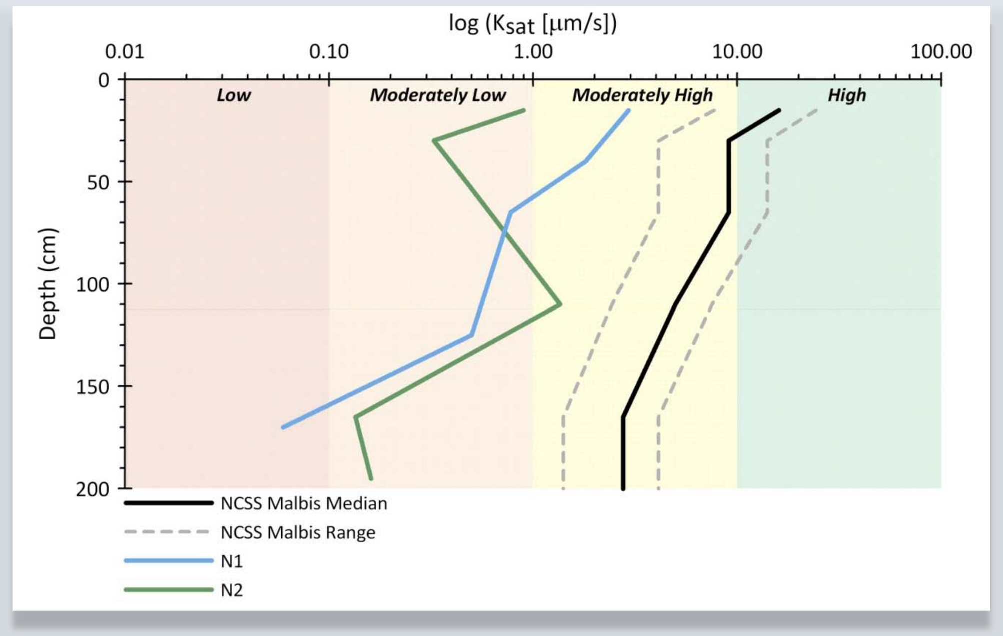

Fig. 3. Comparison of measured and NCSS estimated K_{sat} values

...Results and Discussion

- % plinthite related to log(K_{sat}) (p-value < 0.02)
- HYDRUS -1D simulations somewhat effective for predicting saturation for N1; less so for N2
- 1 saturated & 1 unsaturated event correctly predicted for N1 in five 10/20 day simulations using fitted parameters

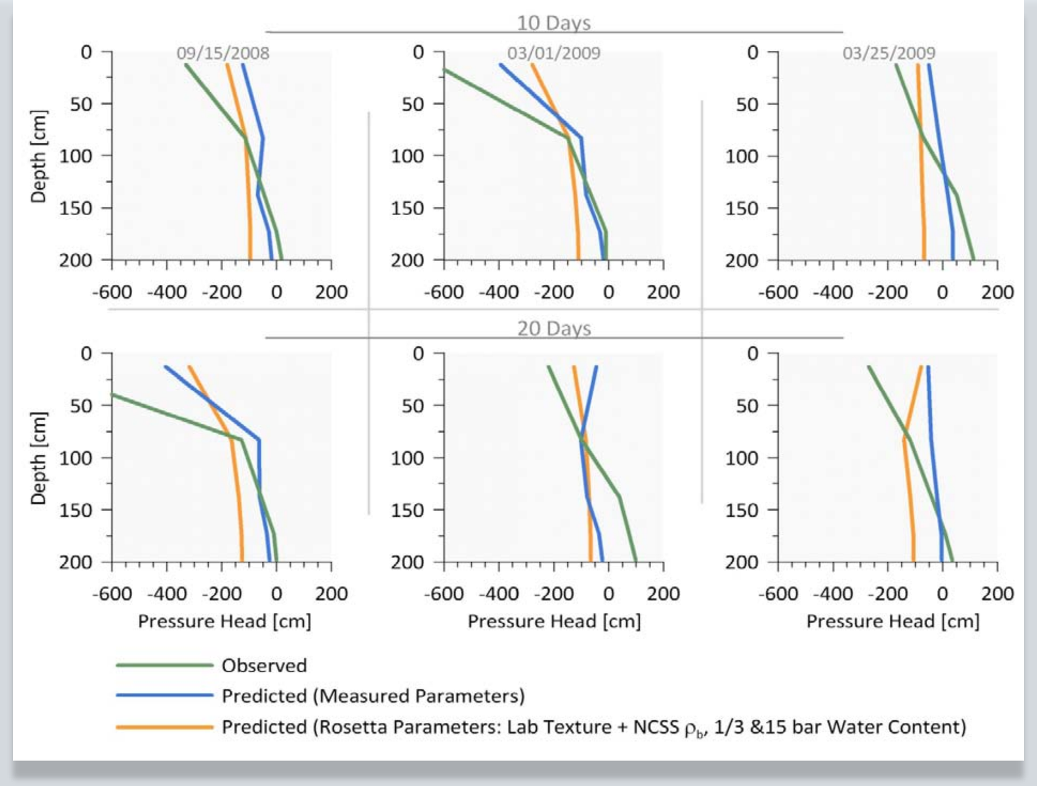

Fig. 4. Field observations and HYDRUS 1D simulation predictions by depth.

- 62 and 46% reduction in RMSE with fitted parameters over Rosetta estimates for N1 and N2, respectively

Conclusions

- For this soilscape, hydromorphology, including plinthite, related to contemporary saturation
  - Other studies have not found this degree of relationship with plinthite (Smith et al., 2007)
- Measured K_{sat}'s generally lower than NCSS estimates, and related to plinthite quantity
- HYDRUS-1D simulation accuracy landscape dependent
- Fitted parameters more effective in these simulations than Rosetta estimates

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