Soil hydrological properties of a tropical basin: the case study of the Beninese part of the Niger River

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Background

Climate is one of the main drivers of soil variability. West Africa is a zone of high spatial and temporal rainfall variability. Moreover, the scarcity of soil data in this region often limits the development and application of physically-based hydrological models.
Beyond the objective of bridging the gap between available soil data and the demand of physically-based models, the influence of rainfall regimes on soil hydrological properties is investigated.

Research question

To what extent do rainfall regimes influence soil hydrological properties? Is there a significant difference between the hydrological properties for a given soil type under different rainfall regimes?

Data

ORSTOM soil map of Benin and isohyets of the period 1970-2010.

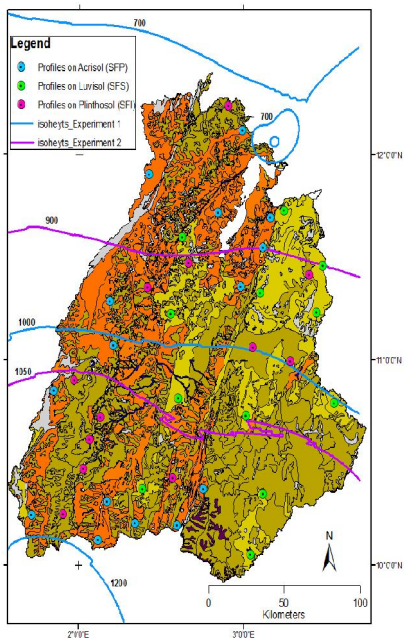
Study area

Four tributaries of the Niger River (40,000 km^2)

Rainfall:
Mean value 936 mm (700-1250 mm), northward gradient: -206 mm/degree.

Temperature:
Mean values: (21.5-34.6°C), northward gradient: +0.59°C/degree.

Soil:
23 % Albic Plinthosol,
21% Haplic Lixsol,
20% Ferric and Albic Acrisol
16% Chromic Luvisols.



Methods: Experimental design

Experiment 1: Use of isohyets to split the soil map into 2 pedo-climatic zones (PCZ): south (1200-1000 mm) and north (1000-700mm).

Experiment 2: Splitting the area in 3 PCZ: south (1200-1050 mm), centre (1050-900 mm) and north (900-700).

Within each PCZ: auger survey, selection and description of representative profiles and sampling (disturbed and undisturbed) of topsoil and subsoil.

Methods: Laboratory and statistical analyses

Laboratory: texture, bulk density (BD), organic matter content (OM), saturated hydraulic conductivity, field capacity (FC), permanent wilting point (PWP) and available water content (AWC).

Statistical analyses: arithmetic mean and coefficient of variation; Mann-Whitney test at 5% significance level for Experiment 1; Kruskal-Wallis and Mann-Whitney tests at 5% significance level for Experiment 2.

Results

No significant difference of topsoil properties between the PCZ regardless of the soil type.

Experiment 1:
Significant difference between the BD of subsoil for all soil types (Table).

Significant difference between the Ks of Acrisol subsoil.

Significance difference between the FC, PWP and AWC of Luvisol subsoil.

Experiment 2:
Kruskal-Wallis test confirmed the significant difference regarding the BD of Plinthosol subsoil and Luvisol subsoil as well as the Ks of Acrisol subsoil.

Mann-Whiney confirmed the significant difference of the BD of Plinthosol subsoil and the KS of Acrisol subsoil.

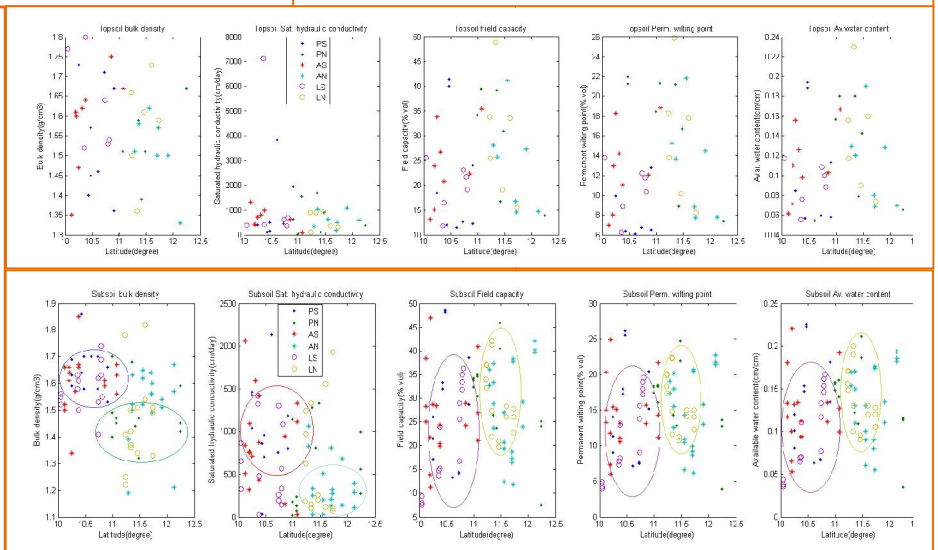


Figure: Comparison of properties with respect to the location, upper Figure topsoil, lower Figure, subsoil. PS: Plinthosol in the south, PN: Plinthosol in the north, AS: Acrisol in the south, AN: Acrisol in the north, LS:Luvisol in the south, LN: Luvisol in the north

Table: Bulk density (g/cm3) of Experiment 1. Left-hand side, topsoil and on right-hand side, subsoil

Soil type	Location	Mean	Coef. Var	p_value
Acrisol	S	1.589	0.078	0.132
	N	1.516	0.062	
Luvisol	S	1.633	0.077	0.589
	N	1.575	0.083	
Plinthosol	S	1.544	0.095	0.605
	N	1.495	0.089	

Soil type	Location	Mean	Coef. Var	p_value
Acrisol	S	1.611	0.064	0.028
	N	1.532	0.084	
Luvisol	S	1.58	0.052	0.005
	N	1.457	0.116	
Plinthosol	S	1.655	0.052	0.002
	N	1.488	0.072	

Limitations

We did not succeed in having the same number of sites for each PZC (soil types unevenly distributed and accessible).

Despite its predominance, Haplic Lixisol was not considered in this study for it was mainly found in the south.

Conclusion

The rainfall regimes impact subsoil hydrological properties, at a greater extent BD and Ks and at a lesser extent FC, PWP and AWC. No significant difference was recorded for topsoil properties.

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