Examination of the effect of biochar on soil resistivity and polarisation

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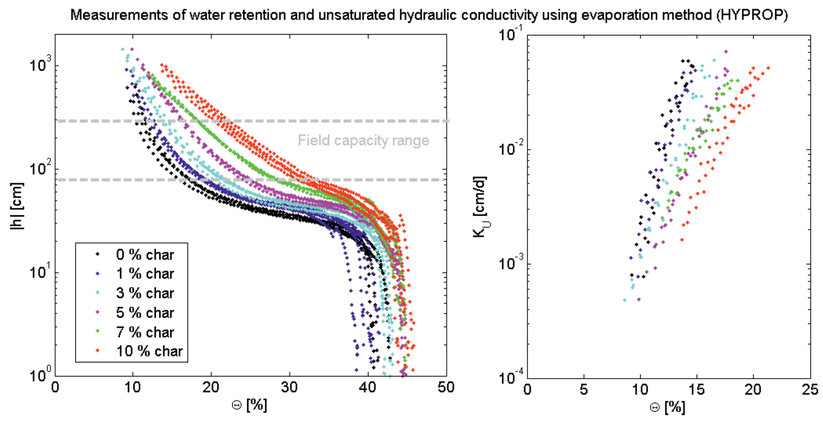
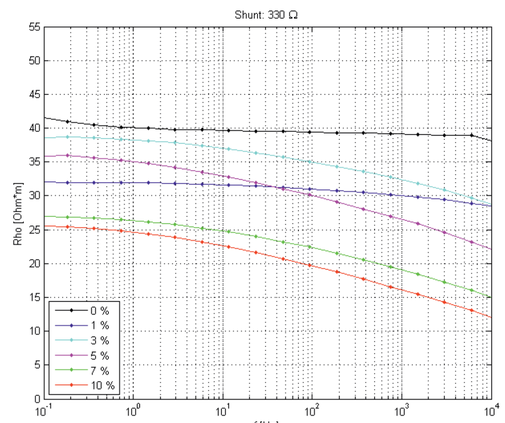
Introduction

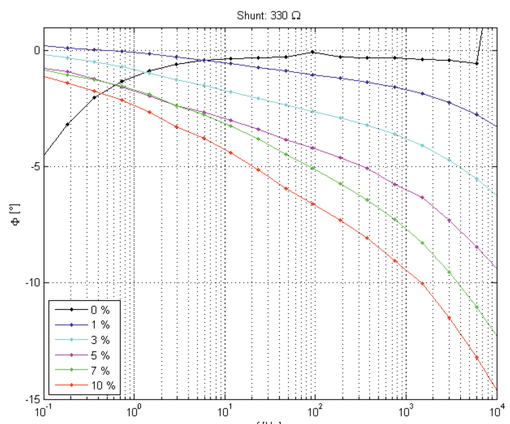
Electrical resistivity tomography (ERT) is widely used to study flow and transport in the saturated and unsaturated zones. The advantage is the minimal invasiveness which enables observation without destroying structures probably significant for the processes. ERT can be used on small, medium and even field scale although the resolution decreases with scale. In this study we show that the water retention capability of biochar admixtures observed on small scale could not be verified on lysimeter scale.

Changed water retention on small scale

Biochar admixture to soil is expected to enhance the water retention. We measured this effect using the HYPROP-System, i.e., using the evaporation method (Peters and Durner, 2008). The parent material is sandy soil (<10% silt) and a varied biochar amount from 1 to 10% by weight is added. As more biochar as higher is the water retention and as lower is the unsaturated hydraulic conductivity. The effect can be quantified as a significant change of the van Genuchten-Mualem parameters. In particular, the increasing water content at field capacity is clearly correlated with the biochar content.

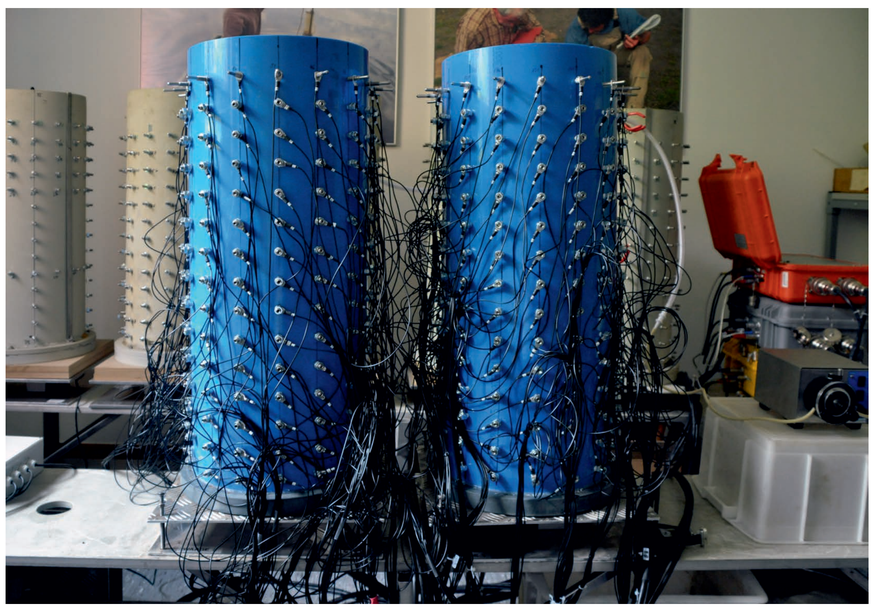






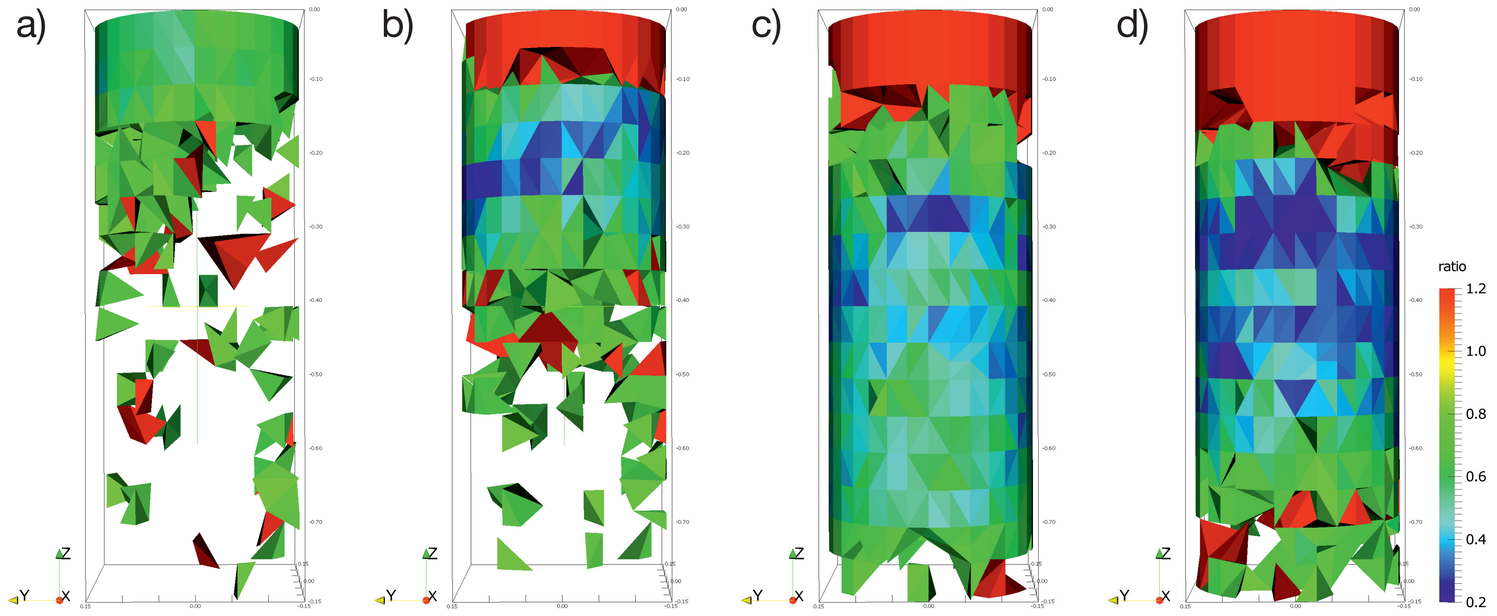
Results of the spectral induced polarisation measurements

Biochar changes the electrical impedance characteristics of the soil. To quantify this effect, we conducted spectral induced polarization (SIP) measurements using cylindrical samples of 10 cm length and 5 cm diameter similar to the dimensions of the HYPROP-samples. As biochar is added, the electrical resistivity decreases with frequency, while the phase shift increases. The reason is the polarisation of the biochar particles. These findings can help to quantify the biochar content non-invasively on field or technicum scale in future experiments.



The lysimeter experiment

We used 3D resistivity tomography (ERT) to observe the effect of biochar admixture on broader scale using two lysimeters (80 cm hight, 30 cm diameter). One lysimeter is filled with sand and in the other the top layer (20 cm) comprises sand mixed with 3% biochar. The lysimeters are firstly saturated with water, then the water is pumped out. Thereafter the lysimeters are sprinkled with 3.6 l of water within 4 hours and the ERT observation continues for 2.5 days.



Results of the ERT measurements

Contrary to expectation the biochar admixture seems not to retain the water within the 20cm layer. The upper figures (a,b,c) show the resistivity ratio 1h, 3h, and 6 h after start of sprinkling within the lysimeter without biochar.

The green/blue colours mark areas where the resistivity decreased due to increased water content. At the surface of the lysimeter evaporation increases the resistivity (red colour). Figure d shows the resistivity distribution within the lysimeter with biochar 6 h after start of sprinkling. No significant difference to figure c is seen. The measurements at later times revealed slow water movement towards the bottom of the lysimeters. The data fit of the inversion was in both cases about 10% RMS.

Conclusion

The addition of biochar to sandy soil changed on small scale markedly the water retention capability and this could be quantified using the van Genuchten-Mualem model. The biochar admixture also changed the resistivity of the soil and caused a spectral induced polarisation effect. On lysimeter scale the increased water retention capability could not be verified. It appears, however, that the addition of biochar increases the evaporation close to surface and further studies are needed to test this hypothesis beyond doubt.

References

Peters, A. and Durner, W. (2008), Simplified evaporation method for determining soil hydraulic properties, Journal of Hydrology, 356, 147 – 162.