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Impact of soil texture and heterogeneity on complex interactions between surface soil salinity and saltwater intrusion in coastal regions

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Soil salinization, referring to the excessive accumulation of soluble salts in soil to a degree that adversely influences vegetation and environmental health, is an unfolding challenge threatening soil health, vegetation and consequently food security with serious socio-economics implications (Hassani et al., 2020, 2021). High salinities in the root zone reduce water and nutrient uptake and result in soil infertility, freshwater contamination at the surface and the loss of biodiversity.

Here, we concentrate on soil salinization in coastal areas due to saltwater intrusion and the groundwater salinization, partly influenced by climate change. In low-lying coastal regions where, saline groundwater levels are shallow, saltwater intrusion poses risks to vegetation and soil health since the soluble salt could be transported toward the surface. This causes soil salinization depending on the competition between upward capillary forces and the limiting downward gravity and viscous forces. Several parameters influence such a competition including soil texture and heterogeneity. We developed a quantitative framework, using software package FEFLOW, to delineate the regional impact of soil textures and arrangements on salt transport toward the surface in low-lying coastal regions. The model includes a wide range of hydrologic, soil and climate related factors such as hydraulic heads, soil properties, and groundwater recharge. We evaluated the performance of the developed model using field data measured in the "*Alte Land*" located in north Germany near the Elbe estuary - an agriculturally significant low-lying region threatened by increasing soil surface salinity.

The evaluation of the model against field-data was followed by conducting the simulation under several hypothetical scenarios differing in soil textures, layering and arrangements to investigate how these parameters would influence soil surface salinity driven by the saltwater intrusion in coastal areas. Our results highlight the prominent effects of different soil textures and arrangements on the regional surface soil salinity and the amount of salt deposited close to the surface. This agrees with the conclusions of laboratory experiments which were conducted in other studies at scales much smaller than the one investigated in our analysis (Shokri-Kuehni et al., 2020). Our results suggest that an effective soil remediation strategy for salinity treatment would require high resolution 3D mapping of soil properties which influences soil salinization. Our

findings shed new light on the dominant parameters influencing surface soil salinity in coastal areas threatened by the saltwater intrusion as a result of the projected climate changes.

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