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How does surface salt crystallization influence saline water evaporation from porous media in the presence of a water table?

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Saline water evaporation from soil is ubiquitous in many environmental and hydrological processes such as soil water evaporation, vegetation and crop production. It plays an important role on soil salinity influencing soil health and ecosystem functioning. When the salt concentration in soil substantially exceeds its solubility limit as a result of water evaporation, salt crystallization occurs (1). Although how different parameters such as type of salt, soil texture, angularity of the grains, presence of a water table and atmospheric condition influence the formation (1-6), patterns and dynamics of crystallization is relatively well understood, how exactly the presence of crystalized salt influence the evaporation dynamics is poorly understood with the majority of the previous investigations offering qualitative description. We thus aimed at quantifying the effect of crystallized salt on dynamics of saline water evaporation from porous media under controlled laboratory conditions. To do so, three sets of experiments were conducted using NaCl solutions of 10%, 15%, and 20% (mass basis) in a climate chamber with constant air temperature and relative humidity of 30 ℃ and 30%, respectively. Sandy soil with particle sizes ranging from 0.4 to 0.8 mm and density of 2.65 gr/cm3 was used as the model porous medium packed in cylindrical glass columns (20 cm height - 8 cm diameter). The columns were supplied from Marriott's flasks to keep the columns fully saturated during the evaporation experiments. Mass loss from sand samples was measured digitally while crystallization dynamics and their corresponding thermal signatures were monitored with a high resolution optical camera and a thermal imager, respectively. This setup enables us to quantify the contribution of crystalized salt on evaporation. Our preliminary results highlight the key role of salt crystallization on changing evaporation dynamics from sand columns relative to the reference sample supplied with freshwater. Despite the impact of salinity in reducing saturated vapor pressure, we observed enhanced evaporation rates from samples with crystalized salt at the surface by a factor of 4 to 12 (depending on the salt concentration). Furthermore, highly resolved surface temperature dynamics recorded by the thermal camera enabled us to investigate the correlations between the intermittent temperature fluctuations of salt crystals and the evaporative flux from the surface. Our findings provide new insights regarding how the presence of crystalized salt at the surface influences the soil evaporation dynamics.

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