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Isothermal vapour flow in extremely dry soils

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In dry soils hydraulic connectivity within the liquid water phase decreases and vapour flow becomes a significant transport mechanism for water. The temperature or solute concentration of the liquid phase affects the vapour pressure of the surrounding air, thus temperature or solute gradients can drive vapour flows. However, in extremely dry soils where water is retained by adsorptive forces rather than capillarity, vapour flows can also occur. In such soils tiny changes in water content significantly affect the equilibrium vapour pressure in the soil, and hence small differences in water content can initiate vapour pressure gradients. In many field conditions this effect may be negligible compared to vapour flows driven by other factors. However, flows of this type are particularly significant in a new type of subsurface irrigation system which uses pervaporation, via a polymer tubing, as the mechanism for water supply. In this system, water enters the soil in vapour phase. Experiments were performed in laboratory conditions using marine sand that had previously been oven dried and cooled. This dry sand was used to represent the desert conditions in which this irrigation system is intended for use. Experimental results show that isothermal vapour flows can significantly affect the performance of such irrigation systems due to the rapid transport of water through the soil via the vapour phase. When the irrigation pipe was buried at a depth of 10cm a vapour flow from the soil surface was observed in less than 2 hours. These flows therefore affect the loss of mass into the atmosphere and thus must be considered when evaluating the availability of water for the irrigated crop. The experiments also provide a rare opportunity to observe isothermal vapour flows initiating from a subsurface source. Such experiments allow the significance of these flows to be quantified and potentially applied to other areas of arid zone hydrology.