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The importance of the poikilohydric nature of lichens as natural tracers for delta18O of ambient vapour

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The stable isotope composition of water is routinely used as a tracer to study water exchange processes in vascular plants and ecosystems. To date, no study has focussed on isotope processes in poikilohydric organisms (i.e. lichens and bryophytes), where relative water content equilibrate with the surrounding humidity conditions and that are able to use distinct water sources such as precipitation, dew, fog and also water vapour. Moreover, lichens are ubiquitous organisms, and on a global scale, they are found in nearly all terrestrial ecosystems and also within these ecosystems they inhabit many microhabitats. As poikilohydric. especially green algal lichens are known to photosynthetically reactivate solely upon uptake of atmospheric moisture, even at non-saturated ambient humidity conditions.

To understand basic isotope exchange processes on non-vascular plants, thallus water isotopic composition was studied in various green-algal lichens exposed to desiccation. The study indicates that lichens equilibrates with the isotopic composition of surrounding water vapour. We found that the thallus water of lichens exposed to high relative humidity shows fast isotopic equilibration with the surrounding vapour regardless of whether the lichen experiences water loss or vapour uptake. The time until isotopic equilibrium is achieved depends on the initial water status as well as on the lichen's specific morphology. It ranged from 5 to 12h in previously dried lichens to approximately 40h in lichens previously rehydrated with liquid water of distinct isotopic composition.

Even though markedly slower, isotopic equilibration between leaf water and ambient vapour may also occur in homoiohydric plants exposed to high relative humidity. At low relative humidity, however, the apparent vapour pressure deficit between the evaporative sites and the ambient air and the increased stomatal diffusion resistance generally causes leaf water enrichment. In contrast, poikilohydric lichens lack both constant water supply and stomatal control. Their water status and, consequentially, vapour pressure at the evaporative sites constantly tends to equilibrate with the surrounding air. This specificity signifies the uniqueness of these organisms to be able to isotopically equilibrate with ambient vapour regardless of prevailing relative humidity conditions. These findings are supported by first observations obtained within field studies in a Mediterranean sand-dune habitat in Portugal: Thallus water isotopic composition of exposed growing, epiphytic lichens directly resembled that of ambient vapour throughout a diel course.

A model was developed as a proof of concept for that accounts for the specific water relations of these poikilohydric organisms. The approach incorporates firstly their variable thallus water potential and secondly a compartmentation of the thallus water into two isotopically distinct but connected water pools. Moreover, the result represent first steps towards the development of pikilohydric organisms as a recorder of ambient vapour isotopic composition.