

Estimation of evaporation rate and temperature for water using hydrogen and oxygen stable isotopic ratios

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Both evaporation rate and temperature were estimated from δD and $\delta^{18}O$ values of water before and after evaporation in laboratory evaporation test under uniform temperature condition. Temperature during evaporation process was calculated by the following equation.

$$(\delta D_{ae} - \delta D_{be} - 51.3) / (\delta^{18}O_{ae} - \delta^{18}O_{be} - 7.52) = -0.064 \times \text{temperature} + 7.45$$

δD_{ae} : δD value of water after evaporation, δD_{be} : δD value of water before evaporation, $\delta^{18}O_{ae}$: $\delta^{18}O$ value of water after evaporation, $\delta^{18}O_{be}$: $\delta^{18}O$ value of water before evaporation.

The relation between evaporation rate and hydrogen or oxygen stable isotopic ratio changed with temperature during evaporation process. Then, under each temperature condition, evaporation rate was calculated from hydrogen or oxygen stable isotopic ratio by the following equations.

$$20^{\circ}\text{C}: \text{Evaporation rate} = 1.32(\delta D_{ae} - \delta D_{be}) + 10.96$$

$$\text{Evaporation rate} = 9.90(\delta^{18}O_{ae} - \delta^{18}O_{be}) - 16.36$$

$$25^{\circ}\text{C}: \text{Evaporation rate} = 0.60(\delta D_{ae} - \delta D_{be}) + 15.19$$

$$\text{Evaporation rate} = 3.66(\delta^{18}O_{ae} - \delta^{18}O_{be}) + 10.63$$

$$30^{\circ}\text{C}: \text{Evaporation rate} = 0.45(\delta D_{ae} - \delta D_{be}) + 21.62$$

$$\text{Evaporation rate} = 2.50(\delta^{18}O_{ae} - \delta^{18}O_{be}) + 17.98$$

$$35^{\circ}\text{C}: \text{Evaporation rate} = 1.16(\delta D_{ae} - \delta D_{be}) + 3.15$$

$$\text{Evaporation rate} = 5.81(\delta^{18}O_{ae} - \delta^{18}O_{be}) + 6.47$$

$$40^{\circ}\text{C}: \text{Evaporation rate} = 0.67(\delta D_{ae} - \delta D_{be}) + 20.93$$

$$\text{Evaporation rate} = 3.38(\delta^{18}O_{ae} - \delta^{18}O_{be}) + 20.07$$

$$50^{\circ}\text{C}: \text{Evaporation rate} = 0.83(\delta D_{ae} - \delta D_{be}) + 3.62$$

$$\text{Evaporation rate} = 4.21(\delta^{18}O_{ae} - \delta^{18}O_{be}) + 0.77$$

However, these relations were stable under low humid condition but unstable under high humid condition because isotope effect for evaporation process is influenced by isotopic ratio of vapor and then under high humidity condition, the effect of vapor is eager to be strong.