The Role of Plants in Site and Catchment Isotope Response

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Introduction
For applications of the stable isotopes of water in hydrological modeling, it is often assumed that plants do not strongly alter the isotopic composition of water, based on the observation that plants do not fractionate water isotopes while taking up water (Ziegler et al. 1970, White et al. 1985).

Synopsis
The possible effect of plants on isotope content of runoff in catchments depends on local climate and associated biomes with their typical plant species and life forms.

The effects can potentially and cancel each other in respect of deviation from expected isotopic values or can be mutually exclusive.

To propose a compilation of possible ranges in deviation, eleven biomes - representing the most common ecosystems worldwide - were used.

Model
The isotope balance was established using the equation:

$$\Delta Y = \alpha \Delta T + \beta \Delta P + \delta \Delta Z$$

Selection effects
- Thoughtful environments
  - Thoughtful input in amount and isotopic value
  - In the water entering the first reservoir
  - Isotope effects are minor and range in the order of -0.05 %o to +0.5 %o (H and -1 to +1 %o (D).

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Redistribution effects
Hydraulic redistribution
- The redistribution of water by plants
- To the soil profile
- Potentials of 0.5 to 1 m (Ishida et al. 2005)

Depth selection uptake
- The uptake of water by plants
- To the soil profile
- Potentials of 0.5 to 1 m (Ishida et al. 2005)

Results
- Model runs indicate that processes inferred only documented for plot scale sites has also been observed for other processes in catchment runoff. Observed values range from -0.56 %o/0.02 %o (depth selective uptake) to -0.42 %o/0.02 %o (log drip) and -3.27 %o/0.02 %o (depth effective uptake) to +2.02 %o/0.02 %o (log drip and redistribution).

Literature review
A review of studies on plant physiology and plot scale plant hydrology indicates that several processes do affect the abundance of water isotopes deuterium (H2O) and oxygen-18 (18O) through canopy effects, plant and root water exchange driven to root zone effects. This effects can be grouped into three and are classified as selection, redistribution, and uptake effects.

Selection effects
- The selection of water with high or low isotopic value
- Canopy transpiration
- Evaporation from the leaf surface
- Interception
- Evaporation from the leaf surface
- Interception

Redistribution effects
Hydraulic redistribution
- The redistribution of water by plants
- To the soil profile
- Potentials of 0.5 to 1 m (Ishida et al. 2005)

Results
- Plant physiological processes resulting in isotope effects on the water cycle can be grouped into three effect groups. These effects are documented for mean 0.2 %o/0.03 %o (canopy interception, Krämer et al. 2006) for catchments and up to 13 %o/1 %o for small scale plots (root fractionation, Lin & Steibenberg 1995).

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