Stable isotope-based approach to validate effects of stand structure and understory on soil water in a Japanese forest plantation

Saki Omomo¹, Yuichi Onda¹, Boutefnouchet Mohamed¹, Chenwei Chiu², Takashi Gomi², Sean Hudson¹, Yupan Zhang¹, and Janice Hudson¹

¹University of Tsukuba, Geoscience, Japan
²Department of International Environmental and Agricultural Science (IEAS), Tokyo University of Agriculture and Technology, Japan
Despite the complexity of the effects of thinning on groundwater recharge, such as the soil surface becoming covered with vegetation over time after thinning, the effects of thinning on groundwater recharge have not been studied yet.

Brooks et al. (2009) classified soil water into three types: tightly bound water, mobile water, and preferential flow, showing that tightly bound water is absorbed by plants, while mobile water and preferential flow recharge groundwater and rivers.

Isotope analysis of mobile water and preferential flow should be taken to determine the type of soil water that actually recharges the groundwater.
To investigate the effects of thinning on soil moisture in four plots with different overstory and understory vegetation distributions.

Separate collection of mobile water and preferential flow to determine what water recharges groundwater.

Determine the impact of thinning on groundwater recharge.
**Method**

**Field**

- Open canopy V= (O=+)
- Closed canopy V= (C+)

**Various micrometeorological**

<table>
<thead>
<tr>
<th>Soil moisture content</th>
<th>Radiation</th>
<th>Evaporation</th>
<th>Soil water potential</th>
</tr>
</thead>
</table>

**Collecting data and sampling**

- Weighing lysimeter
- Tensiometer

**Installing zero-tension lysimeter**

- Modular zero tension lysimeter:
  - It can be inserted without breaking soil and have a wide catchment surface.
  - This shape also prevents the release of soil water and improves collection efficiency.

**Various water samples**

- Throughfall
- Mobile water
- Preferential Flow

**Table 1: Catchment area of zero tension lysimeter**

<table>
<thead>
<tr>
<th>P10</th>
<th>P10+</th>
<th>P1C</th>
<th>P1C+</th>
<th>P30+</th>
<th>P3C+</th>
</tr>
</thead>
<tbody>
<tr>
<td>10cm cm²</td>
<td>666</td>
<td>600</td>
<td>640</td>
<td>668</td>
<td>672</td>
</tr>
<tr>
<td>30cm cm²</td>
<td>700</td>
<td>628</td>
<td>552</td>
<td>700</td>
<td>626</td>
</tr>
</tbody>
</table>

**Note:**

- Field: Japan, Tochigi-prefecture, Mt. Karasawa (Field museum of Tokyo University of Agriculture and Technology)
Result: The time series of δO¹⁸ and precipitation

Open rainfall and throughfall

Soil water (suction lysimeter and zero-tension lysimeter)

Fig.1: Time series change of the oxygen stable isotope ratios (δO¹⁸) for open rainfall and throughfall, and the daily precipitation.

Fig.2: Time series change of the oxygen stable isotope ratios (δO¹⁸) for mobile water and preferential flow, and the daily precipitation. (PF: preferential flow)

- Analysis for soil water and throughfall sample of 8/6/19 isn’t finished yet.
- We couldn’t collect much water sample in P1O and P1C. Therefore, We discuss using the data in P1O+, P1C+, P3O+ and P3C+.
- Soil water sampled by the zero tension lysimeter is assumed to be preferential flow, and soil water sampled by the suction lysimeter is assumed to be mobile water.
Discussion: The change of the $\delta O^{18}$ value

![Diagram](image)

Fig. 3: The average of $\delta O^{18}$ value for each water samples in P1O+, P1C+, P3O+ and P3C+.

※Op: open rainfall, TF: throughfall, PF: preferential flow (zero-tension lysimeter), MW: mobile water (suction lysimeter)
※Average is weighted average

- **Mobile water (Suction lysimeter)**
The average of $\delta O^{18}$ value in P1O+ and P3O+ is closer to open rainfall than it in P1C+ and P3C+. The change of $\delta O^{18}$ value for mobile water become smaller as deeper points.

- ** Preferential flow (Zero-tension lysimeter)**
The average of $\delta O^{18}$ value for preferential flow at 30cm and The average of $\delta O^{18}$ value for mobile water at 80cm is very close in P1O+, P3C+.

- **Throughfall**
There is very little difference in the value of $\delta O^{18}$ for throughfall between P1O+, P1C+, P3O+, and P3C+. 
Since the $\delta^{18}O$ values of soil water collected by the zero tension lysimeter are close to the $\delta^{18}O$ values of open rainfall, it is likely that the soil water collected by the zero tension lysimeter is preferential flow. The value of $\delta^{18}O$ for mobile water at 80 cm, which is assumed to be groundwater-recharging soil water, is close to that of throughfall before thinning and close to that of open rainfall after thinning, and the value of $\delta^{18}O$ for groundwater-recharging soil water is likely to be different before and after thinning. In addition, the $\delta^{18}O$ value for preferential flow at 30 cm is assimilated with the $\delta^{18}O$ value for mobile water at 50 cm or 80 cm. These indicate that changes in the value of $\delta^{18}O$ for preferential flow affect the value of $\delta^{18}O$ for soil water that recharges groundwater. The impact of thinning on groundwater recharge could be clarified by determining the percentage of preferential flow in soil water at each depth.