Introduction

Stemflow (SF) is a type of rain partitioning by the forest canopy that rediresct water down tree trunks (FIG 1). During this process, nutrients are leached from tree surfaces delivering highly enriched water to the tree base (FIG 2)[1]. Throughfall (TF) is the water intercepted by the canopy that falls through as enriched water to forest soils[2].

Mechanisms of water exchange during the SF process have not been well established and prevail full integration of this process into hydrologic and biogeochemical models that include small-scale SF water cycles and bark water storage capacities.

Stable deuterium (H/D) and oxygen (O) isotopic tracers can be used to follow water through hydrological cycles. Lighter isotopes (H and O) are more readily evaporated back into the atmosphere from tree surfaces[3,4]. When SF water evaporates from bark surfaces, H and O are preferentially evaporated, leaving the heavier isotopes (D and 18O) in the tree bark (FIG 3)[5,6].

Different tree species (TABLE 1) have unique bark characteristics (FIG 4) and variable effects on rain partitioning[7]. We look to examine species-specific effects on forest hydrological cycles via stable isotopes.

Materials & Methods

Objectives

SF volume and isotopic composition (δD and δ18O) were measured over a one-year period to address three main objectives:
1. Determine origins and pathways of SF water using stable water isotopes.
2. Identify differences in SF generation mechanisms between tree species.
3. Identify differences in SF generation mechanisms between storm events.

Results

This study was conducted at Sessum’s Natural Area (SNA), an old growth oak-hickory stand in Starkville, MS (TAB 1 & FIG 5).

- Storm events with at least 12mm of rainfall were sampled.
- One gross precipitation (PG) gauge was used along with four TF collection apparatuses at SNA (FIG 2) to compare isotopic compositions to that of SF water signatures.
- Water samples were collected in 20mL vials with no head space and later analyzed for δD and δ18O with laser ablation spectroscopy at LSU and expressed relative to the Vienna Standard Mean Ocean Water (VSMOW), according to the following equation:

\[
\delta (\text{‰}) = \left( \frac{R_{\text{sample}}}{R_{\text{standard}}} - 1 \right) \times 1000
\]

where

\[
R_{\text{sample}} = \text{the ratio of heavy to light isotopes in the sample}
\]

\[
R_{\text{standard}} = \text{the ratio of heavy to light isotopes of the standard}
\]

Eight bark thickness measurements were taken per tree, with a bark gauge to determine differences between species (FIG 6); relation to total volumetric records were found for SF, TF, and PG.

- Results suggest lighter isotopes evaporate out of tree bark, leaving heavy isotopes to accumulate in SF water during the next storm event (FIG 9 and 10).

Discussion

- CBO displayed the pattern we expected to see with smooth, medium-bark that generated large quantities of SF (FIG 10) with lower residence time for water on bark surfaces, resulting in lighter isotopic composition of SF.
- A better understanding of isotopic variations between tree species will help determine differences in SF water storage capacity of different species and bark structures. Thorough analysis of these results will allow for more accurate hydrological and biogeochemical models to be established.

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[9] Sessum’s Natural Area. Mississippi, including Populus deltoides, Acer saccharum, and Carya ovata.

Table 2 A description of all collected events at SNA. Excessive rain was too small of volume to accurately analyze: Overview SF, PG.

Figure 1: A schematic of heavy and light oxygen (PO3/PO2) isotopic compositions and processes.

Figure 2: Phylogenetic SF consists of an aluminum nails and silicone caulk; TF collectors consisted of an 8.8cm diameter funnel attached to a Nalgene bottle on a 15m pole.

Figure 3: Map of SNA, Mississippi, including oak-hickory and canopy area of all six experimental species.

Figure 4. Preliminary SF is quite variable between the six species.

Figure 5. Map of SNA, Mississippi, including oak-hickory and canopy area of all six experimental species.

Figure 6. Bark thickness of the six evaluated species at SNA.

Table 2 A description of all collected events at SNA. Excessive rain was too small of volume to accurately analyze: Overview SF, PG.

Figure 8 4D and δ18O isotopic analysis of the six tree species, TF, and PG after all 11 sampled storms. The GMWL shows variation of the SF water due to natural processes of evaporation and condensation at a global scale, whereas the Local Meteoric Water Line (LMWL) exhibits a local scale of variation (see FIG 10).

Figure 9 δ18O isotopic analysis of the six tree species, TF, and PG at a storm event (March 4th, 2016).

Figure 10 SF volume (mL) of PG.” Minimum 4°, 2016” storm had 2.7cm of PG and 2.2cm of TF (76.9% of PG).