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Winter Stemflow Leachate Dynamics from Deciduous Canopy Trees in Relation to Precipitation Event Characteristics

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EXTENDED ABSTRACT

In deciduous forests, midwinter aqueous leaching due to climate change and the increased frequency of mixed precipitation events is poorly understood. The Global Change and Terrestrial Ecosystems (GCTE) research initiative of the International Geosphere-Biosphere Programme has specifically addressed the need for studies investigating the effects of global change on the biogeochemistry of terrestrial ecosystems, arguing that such studies can make significant contributions to our understanding of human-induced transformations of the biosphere. Empirical data collected from this study will reduce the midwinter data gap and enhance our understanding of the seasonality of elemental cycling in forested ecosystems.

An in-situ meteorological station equipped with temperature, humidity, wind and radiation sensors continuously recorded weather conditions over two successive winter seasons (1997–98 and 1998–99). A tipping-bucket snow gage recorded the snow water equivalent for each precipitation event. A precipitation event was defined as a period of measurable precipitation followed by 24 h of dry conditions. Stemflow was collected on a precipitation event basis from representative deciduous tree species, *Quercus rubra* L. (northern red oak), *Carya glabra* Mill. (pignut hickory), and *Betula lenta* L. (sweet birch). Chemically inert stemflow collars were connected to each tree in an upward spiral and funneled stemflow into a 121-L capacity collection bin lined with chemically inert sample bags. All samples for chemical analysis were collected in polypropylene containers within 24 h of the event. Flame atomic absorption spectrophotometry was used to measure concentrations of K^+, Ca^{2+}, and Mg^{2+} in the incident gross precipitation and stemflow samples. The extent of chemical enrichment of stemflow compared to the incident gross precipitation was standardized for each event per unit trunk basal area using an enrichment ratio (E)

$$E = (C * S) / (I * P * B)$$

where C is stemflow ion concentration (mg L^{-1}), S is stemflow volume (L), I is gross incident precipitation ion concentration (mg L^{-1}), P is depth equivalent of incident gross precipitation, and B is trunk basal area (cm^2). The enrichment ratio served as the basis to compare the influence of differing meteorological conditions on aqueous stemflow leaching.

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Precipitation type, storm duration and intensity, and quantity of stemflow generated had detectable and significant influences on leachate quantities from the woody surfaces of deciduous trees. Cluster analysis demonstrated that snow-to-rain events exhibited the most pronounced chemical enrichment. Cold rain and rain-to-snow events showed intermediate levels of chemical enrichment. Icy precipitation events and rain showers were the least chemically enriched. All precipitation events were chemically enriched compared to the bulk precipitation. Enrichment ratios ranged from 25 to 300 for K^+, Ca^{2+}, and Mg^{2+}. Longer, less intense precipitation events were more chemically enriched than events of short duration and higher intensity because of the longer residence time of intercepted precipitation on the tree's woody frame. Magnitude of a precipitation event did not appear to have a significant influence on the extent of chemical enrichment. Stemflow volume was inversely proportional to the degree of chemical enrichment.

Deciduous canopy trees are not chemically inert during winter. Likely due to global climate change, an increased frequency of snow-to-rain events was observed to increase the mobilization of nutrients from above-ground vegetative surfaces to the forest floor as compared to snow events. Elevated dormant season nutrient inputs at the tree base could explain heterogeneous spatial patterning of soil solution chemistry of the forest floor and the timing and spatial development of fine roots in deciduous forests.

Key Words: Deciduous, Leaching, Mixed precipitation, Stemflow, Winter