EXAMINATION OF PLANT WATER STRESS AND GROUNDWATER RECHARGE IN THE MOUNT LOFTY RANGES: AN ISOTOPIC PERSPECTIVE

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To my husband

Guoqiang

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SUMMARY

Climate change may impact both water resources and terrestrial ecosystem structures. For a better understanding of the hydrological and ecological responses to future climate change, it is important to know how recharge relates to climate conditions, how vegetation uses rain water of strong seasonal variation, and how much stress vegetation experienced under current climate conditions. This dissertation is to examine these issues from isotopic perspective based on a study area with a strong hydroclimatic gradient induced by topographic relief.

Upland catchments usually are not only composed of bedrock aquifers, thick fracture-rock vadose zone and thin soil, but also vegetation cover. Experiments were performed on two contrasting hillslopes in a native vegetated catchment – Mount Wilson, to study plant responses to environmental conditions (primarily water stress). Significant seasonal variations in leaf $\delta^{13}C$ are observed for both studied C_3 tree genus up to 1.7‰ for *Eucalyptus* Leucoxylon and up to 2.7‰ for *Acacia Pycnantha.* Temporally, the linear correlation coefficients between leaf $\delta^{13}C$ and aridity index (PET/P) can be as high as 0.45. Spatially the correlation coefficient is 0.34 for *E*ucalyptus species. This result suggests that PET/P may be applied to quantify the relationship between leaf $\delta^{13}C$ and plant water stress.

Stable isotope water composition of precipitation is of importance as input characterization to trace recharge sources of groundwater. In vegetated catchments, the input water isotopic composition is altered from precipitation. Based on one year throughfall monitoring for both ^{18}O and *d*-excess at two vegetated surfaces in Kuitpo Forest, South Australia, the results indicate that isotopic alteration can be significant in densely vegetated catchments and is important for hydrograph separation studies, but can be negligible for tracing groundwater recharge sources.

Water isotopic composition is also used to examine how vegetation uses rain water in a typical Mediterranean climate. One-year monitoring of $\delta^{18}O$ and $\delta^{2}H$ in twig water is applied to understand the root zone moisture replenishment. The response of $\delta^{18}O$ and $\delta^{2}H$ of twig water to the rain events indicates that landscape water storage capacity of winter rain is important for plant growth and survival during dry summer. The results of the $\delta^{18}O$ and $\delta^{2}H$ of groundwater had a mean value -5.1‰ and -27.5‰ respectively and that of throughfall in the wet season had a mean value -5.1(±1.7)‰ and -23.4(± 13.3)‰ correspondingly. They indicate that groundwater recharge is dominated by events in the wet season.

Extended from this small catchment, water isotopic composition is used to examine groundwater recharge seasonality over the whole Mount Lofty Ranges. Based on this understanding, an improved storage-discharge relationship-based method (SQR) is proposed to estimate groundwater recharge for mountainous catchments. Net catchment recharge estimates varies between 1.3 mm/year and 13.5 mm/year. Especially, recharge estimates from catchment Onkaparinga River at Hahndorf using SQR method is (7.0 mm/year) close with that from the independent chloride mass balance estimation (3 mm/year). Good correlation between annual direct water-table recharge and aridity index suggests that this method can be used to examine dynamic responses of groundwater recharge to the climate conditions in mountainous regions.

DECLARATION

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

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