Isotope Analysis for Understanding Mountain Springs in Western Nepal

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Project Background

Springs are a major source of water in the hills and mountains of Nepal. Since 2014, with funding from the Asian Development Bank and the Nordic Development Fund, the "Building Climate Resilience of Watersheds in Mountain Eco-Regions" (BCRWME) project is working to provide 45,000 households in vulnerable mountain communities with access to more reliable water resources via spring or surface water sources. Despite the recognition of springs as a livelihood driver in these communities and the observed alarming trends in the drying up of springs, a scientific understanding of mountain springs in Nepal has not been established. Under BCRWME, the International Water Management Institute (IWMI) is leading comprehensive research into characterizing mountain springs and identifying science-based interventions that can increase reliability and water availability in these sources. IWMI is conducting isotope analysis to investigate hydrological processes in mountain springs and identifying recharge zones in order to sustain springs in Banlek and Shikarpur in western Nepal.

Climate (left) and hydrological (right) monitoring stations have been setup at the study sites to gather hydro-meteorological data. Shown are stations in Shikharpur.

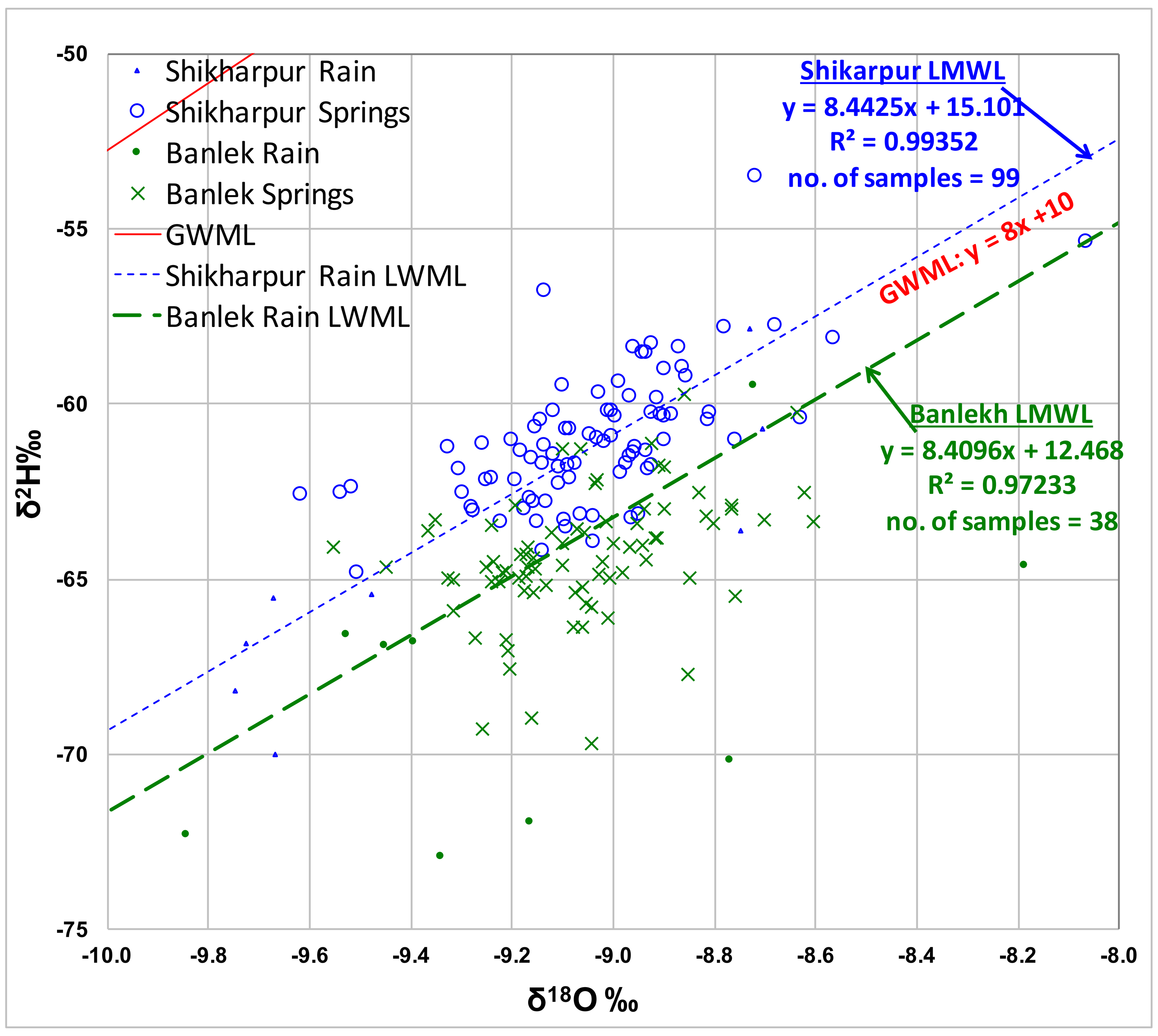
Isotope Analysis

Water consists of hydrogen and oxygen that have different isotopes. When water moves through the hydrological cycle, fractionation changes the ratio of isotopes present in the water molecule. As a result, isotopic composition of water can be used to identify its source (rain, snow, surface runoff or aquifer) or processes (evaporation, condensation, altitude effect, continental effect. etc.) resulting in its formation. The global meteoric water line (GWML) describes the correlation between ^{18}O and ^{2}H seen in rainwater globally. The local meteoric water line (LMWL) can be established based on isotopic composition of rainwater collected locally. Deviation between GWML and LMWL is indicative of local processes guiding rainfall in the region. Similarly, isotope composition of samples from water sources relative to the GWML and LMWL describe the processes and resulting changes in isotopic composition the water has undergone prior to reaching the source.

The study areas in Banlek and Shikharpur consist of 4 springs each. Banlek covers 1.74 sq km between 700-1100 masl while Shikharpur covers 3.74sq km comprising of steeper slopes between 1900-2500 masl. Water samples were collected from surface water (springs, streams and river) weekly in wet season (June-September) and fortnightly in dry season. Rainwater or snow was collected at three different elevations for all rain events >5mm throughout the year. A total of 422 water samples were collected and analyzed for ^{18}O and ^{2}H isotopes at the Stable Isotope Laboratory in the National Institute of Hydrology, Roorkee, India.

Preliminary Findings

The LMWLs based on all year round precipitation samples at Shikharpur and Banlek have higher slopes and y-intercepts. The greater isotopic fractionation of ^{18}O and ^{2}H with condensation during rainfall results in disproportionate depletion of 18O relative to ^{2}H and a higher slope for LMWL. Lower temperature and humidity in the source area for the vapor that the rain is derived from yields large y-intercepts. Disaggregation of rain by season reveals that Banlek rain from the wet season lies below or on the GMWL. The vapor source for the rain has undergone evaporation and consequently suggests that the source of the wet season rain is vapor from the warmer and humid Bay of Bengal, driven by monsoon winds. About 50% of wet season rain samples in Shikharpur lie above GMWL, which suggests higher local events bringing rain. In the dry season, rain in Shikharpur is much more enriched than wet season rain, indicating a colder and more arid vapor source driven by the westerlies.



Isotopic composition of rainwater and spring samples, collected over wet and dry seasons, are overlaid with the GWML (red) and estimated LWML. Shikharpur data is shown in blue and Banlek in green.

The isotopic composition of most springs in Shikharpur lie above the LMWL of wet season rain and below the LMWL of dry season rain, suggesting their recharge source to be dry season rain and rain or snow melt from higher elevation with different sources of moisture, wind speed and temperature. Springs in Banlek lie closer to or below the LWML suggesting an altitudinal effect on the moisture originating from warmer areas. Wet season rain appears as the major recharge source for these springs. Based on correlation of sampling altitudes with isotopic composition of rainfall and spring samples, the recharge altitude for Shikharpur springs are estimated at 2465-2723m masl. Based on site assessment, a swale-like depression at the top of the hill is a potential recharge area for Shikharpur springs. The recharge elevations are estimated between 998-1105 masl for Banlek, indicating that the glacial valley on the opposite face of the hill at 1075-1077m elevation is a potential recharge zone for Banlek springs. Isotope analysis complemented by hydro-meteorological monitoring and watershed modeling is improving our understanding of springs and helping develop management interventions to effectively recharge springs in western Nepal.

The field assistant above takes samples of rain water in Shikharpur for isotope analysis.

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