Government of Nepal
Ministry of Forest and Soil Conservation
Department of Soil Conservation and Watershed Management
Building Climate Resilience of Watersheds in Mountain Eco-Regions Project (PPCR1)

Isotope Analysis in the BCRWME Project

Project Background

In 2014, the Asian Development Bank and the Nordic Development Fund joined the Government of Nepal in establishing an ambitious six-year project titled, "Building Climate Resilience of Watersheds in Mountain Eco-Regions", or BCRWME. The project aims to **provide 45,000 households in vulnerable mountain communities with access to more reliable water resources** via spring or surface water sources. The International Water Management Institute (IWMI) is leading a package in the overall project, a comprehensive research study titled, **"Watershed Hydrology Impact Monitoring Research in Far West Nepal"**, focusing on Baitadi and Doti districts. The International Water Management Institute (IWMI) has established a field monitoring network to collect climatic and hydrogeological data, collect samples for isotope analysis and to develop a comprehensive hydrological model of surface and groundwater in the study watersheds. The main partners are the Department of Soil Conservation and Watershed Management (DSCWM) technology development section, Institute of Forestry (IOF), Groundwater Resource Development Board (GWRDB) and National Institute of Hydrology (NIH). This will provide the larger BCRWME project with the information necessary to **implement effective watershed management interventions** in the entire project area.

What are Isotopes, and why are they important?

Isotopes are atom species that have differing atomic masses, due to additional neutrons. Analyzing the ratio of these different types of atoms improves our understanding of spring system hydrology and is useful in planning management interventions that recharge springs.

Specifically, scientists can determine:

1) where the recharge area is located
2) the source of the spring water (rain, snow, surface water or groundwater)
3) how long water sits in the recharge aquifer before emerging from the spring.

For mountainous communities, springs are often the main source of drinking and irrigation water. However, the drying up of these springs has not been studied adequately. project researchers are collecting isotope, hydrological and climate data in order to comprehensively model and understand this issue.

IWMI International Water Management Institute

1 *Where is the recharge point for each spring?*

Why is this important?

Knowing the recharge elevation will enable the project to **better pinpoint where to implement interventions** like dams and catchment basins in order to most effectively improve spring recharge. The recharge elevation can be used alongside the project's hydrogeological studies to find precise intervention locations.

How does it work?

The Basics:

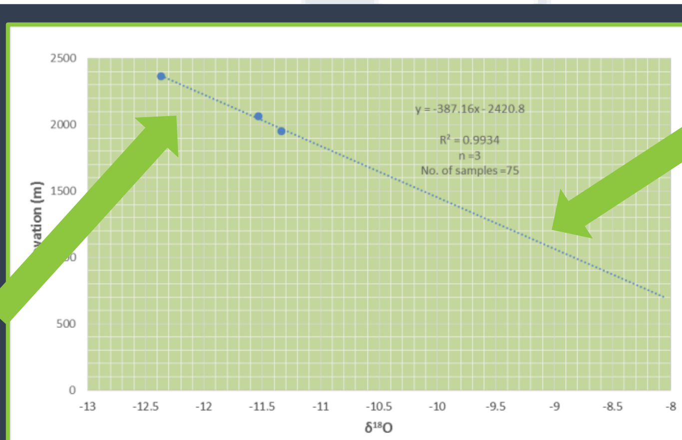
When scientists test spring water, they are able to determine at what elevation most of that water percolated into the ground. This location is known as the *recharge area*. They are able to do this because of two natural phenomena. Firstly, the **water that falls as rain at higher elevations has a different isotopic composition** than rain at lower elevations. Secondly, **water changes as it runs down the mountain** and is exposed to air. Researchers test precipitation and stream water from various elevations, and then use an equation to determine at which elevation most recharge occurs.

The Specifics:

It is the ratio of lighter oxygen isotopes (^{16}O) to heavier oxygen isotopes (^{18}O) that determines recharge elevation. A ratio higher in ^{16}O than ^{18}O indicates that spring water recharge occurs at higher elevations. The first reason for this is that rainfall at a higher elevation contains more ^{16}O. **Heavier ^{18}O falls as rain sooner**, which means that much of it has already fallen by the time the clouds move from the sea to the mountains. Secondly, **stream water becomes "heavier"** (has a higher concentration of ^{18}O) **as it proceeds down the mountain**. The lighter ^{16}O leaves via evaporation, leaving ^{18}O behind. Both of these processes mean that if spring water samples have higher levels of ^{16}O, the recharge point must be at a higher elevation.

Analyzing results

Preliminary Results: Established the equation (graphed here) of the isotope ratio found in precipitation samples across various elevations. This can be used to locate the recharge area.



On this side of the graph, there are more light oxygen atoms. This means that **the spring water came from a higher elevation.**

On this side of the graph, there are more heavy oxygen atoms. This means that **the spring water came from a lower elevation.**

2 What is the source of the spring water?

Why is this important?

Scientists can determine if spring water came from this year's rain, accumulated snow, surface water (streams, rivers) or groundwater. After determining the source, the project can choose the type of intervention that will most effectively recharge the spring. For rain and snow, earthen ponds may collect and recharge the most water. For surface and groundwater, the best choice will likely be dams and catchment basins. This research will also establish a local baseline for the four water sources, which future projects can use to improve their own water management interventions.

How does it work?

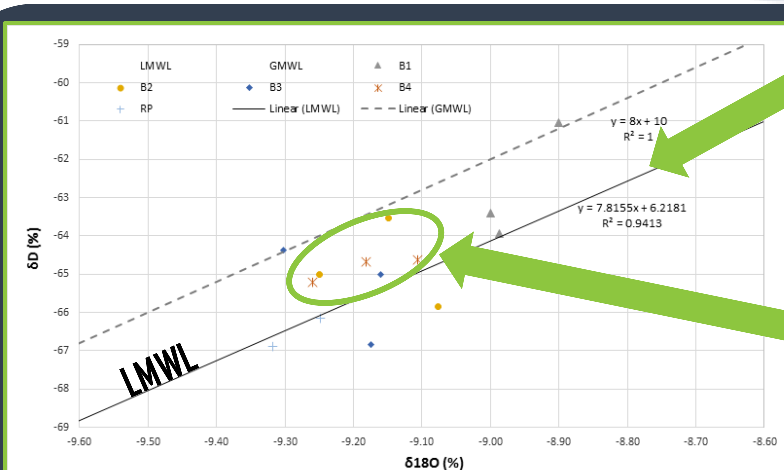
The Basics:

Does the water emerging from the spring originate mostly from rain, snow, surface water (i.e. a stream) or groundwater? Scientists can answer this question by **establishing an *isotopic signature* for each source possibility**. This signature is a unique isotope ratio. Like a thumbprint, it shows researchers from which source it came. To determine the isotopic signature, field assistants collect snow, rain, surface and groundwater samples from various precipitation events across different seasons. Researchers use that data to establish isotopic signatures for each type of source. The signature that most resembles the actual isotope ratio of the spring sample is the predominant source of the spring water.

The Specifics:

Scientists analyze the ratio of oxygen and deuterium (an isotope of hydrogen) from samples of rain, snow, surface and groundwater. The correlations between the two elements are used to establish and graph a Local Meteoric Water Line (LMWL) for each source. So far, project researchers have created the LMWL for rain. After creating an LMWL, spring water samples are collected and their ratio of oxygen to deuterium is determined. **If it falls near the LMWL, then the spring water was predominantly fed by rain from that year**. If not, the spring water came from either accumulated snow, surface or groundwater, and those sources are tested.

Analyzing results

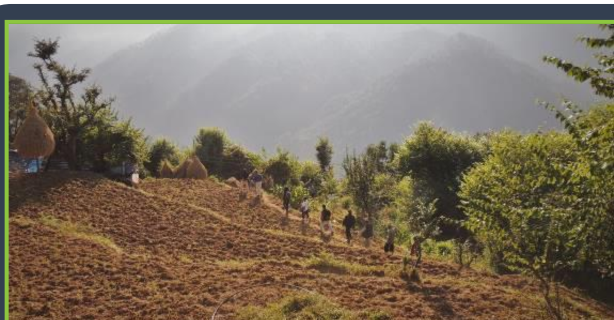


This is the line that researchers have established based on **isotope samples of rainwater**. The dots are spring water samples.

Preliminary Results: Most spring water samples taken are not along the solid line, meaning that this year's rain is not the primary source of spring water. Now project researchers will follow the same process for accumulated snow, surface and groundwater.

3 How long is water in the underground aquifer before emerging from the spring?

Why is this important?



Understanding how much time water spends in its underground aquifer will **vastly improve the body of knowledge on water management for the region**. Commonly referred to as the "age" of water, it is an important facet in understanding overall aquifer storage capacity. Knowing how much water an area can hold can help implementing partners design projects with maximized long-term sustainability.

How does it work?

The Basics:

The concentration of tritium in rain water changes over time. Therefore, researchers can **test tritium concentrations in spring water samples to determine in what year the rain fell**. The time between when the rain fell and when it emerged from the spring is roughly the amount of time it spent underground, in the recharge aquifer.

The Specifics:

Nuclear bomb testing of the early 1960s filled the atmosphere with tritium (^{3}H), an unstable isotope that over time reverts into ^{3}He. Therefore, **rain with higher tritium concentrations is older** (it fell closer to the 1960s), while rain with lower tritium concentrations fell more recently.

References

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Research and factsheet by IWMI

BCRWME
Project Office: Tufandada, Amargadhi-5, Dadeldhura
Phone: 977-096-410236

Liaison Office: Babarmahal, Kathmandu, Nepal
Phone: 977-01-4241487
Email: info@bcrwme.gov.np

IWMI Headquarters
127 Sunil Mawatha, Pelawatte, Battaramulla, Colombo, Sri Lanka
Mailing address: P. O. Box 2075, Colombo, Sri Lanka

Tel: +94 11 2880000, 2784080
Email: iwmi@cgiar.org
Fax: +94 11 2786854
Website: www.iwmi.org