Heaping dividends for Isotope Hydrology

Through Global Partnerships

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Two-thirds of the Earth's geographical surface is covered by water, however, most of it is not ideal for drinking purposes and the resources used by mankind comes mainly from underground aquifers. Usually, such aquifers remain connected to rivers and surface water bodies and hence have inflows during dry seasons and feed the associated lakes and rivers during wet seasons. Despite the voluminous occurrences of waterbodies, still we are not certain about the sustainability of these waterbodies for our future generations. Climate change, over-extraction and anthropogenic pollutions (due to mining, textile industries, livestock farming) are some of the key factors altering the rates of feeding and replenishment of a given 'hydrological cycle' (evaporation, precipitation, infiltration, runoff, returning to ocean/atmosphere).

The recently published United Nations data (WHO/UNICEF Joint Monitoring Program Report 2023) pertaining to SDG-6 (Sustainable Development Goal – Clean Water and Sanitation) suggests that of the current over 8 billion population, 2.2 billion (~1 in 4) live without safely managed drinking water, and approximately 1.8 billion people still lack access to drinking water on-premises. As per the World Meteorological Organization (WMO) Report 2021, there are about 2 billion people living in countries under 'water stress' and ~3.6 billion face 'inadequate access to water' at least a month. As per the World Health Organization (WHO) 2023 report, nearly 1000 children, below 5 years, die every day due to consumption of unsafe water, sanitation and hygiene. Rough assessments suggest that at least 6 times faster improvements are needed in the domains of safely managed drinking water to achieve SDG-6. Achieving this goal NOW is crucial, as any delay will make the future challenge exponentially more difficult.

As per the World Population Prospectus (2024) shared by Department of Economic and Social Affairs Population Division (UN DESA/POP/2024/TR/NO.9), 'the world's population is expected to continue growing over the coming 5-6 decades, reaching a peak around 10.3 billion people in the mid-2080s. Following this, it will decline marginally to 10.2 billion by the end of this century. This population growth curve is expected to shape up differently among the SDG regional groupings e.g. Sub-Saharan Africa, Northern Africa and Western Asia, Central and Southern Asia, Eastern and South-Eastern Asia, Latin America and the Caribbean, Australia and New Zealand, Oceania, Europe and Northern America, including 'Least Developed Countries (LDC)', 'Landlocked Developing Countries (LLDC)' and 'Small Island Developing States (SIDS)'.

Overcoming Challenges

The only way out to address these challenges is through effective and sustainable water resource management. Respective Governments along with their responsible laboratories and organizations should invest its resources to develop robust and effective strategies, which should integrate real-time feedback mechanisms, at regional, interregional levels and national levels, responding to the changing demands and futuristic needs efficiently. In such efforts key roles are to be played by

- *Isotope Hydrology techniques for sustainable water management* for drinking water, irrigation and

industrial sectors by tracking the movement of water through respective hydrological domains, tracing the original source of groundwater, and examining possible mixing processes.

- *Continuously upgrading the methodologies* for water resources evaluation, both its quantity & quality.

Capacity building will be another important aspect to address the water security issues in future. Training and state of the art infrastructure for isotope hydrology laboratories are absolutely necessary to prepare young professionals for data acquisitions, monitoring and interpretations. On the whole we require concerted global efforts to safeguard the water resources for future use.

International Concerted Efforts

The International Atomic Energy Agency (IAEA) is playing crucial roles in all the domains mentioned above through application of '**isotope hydrological techniques**' (oxygen-18, deuterium and tritium of water molecule) as promising tools. In recent times naturally occurring tracers e.g. hydrogen (tritium), carbon (carbon-14) and noble gases (helium-3, helium-4 and krypton-81); and other isotopes like boron-11, nitrogen-15, and sulfur-34, etc. are being explored for identifying the pollutant sources.

The Agency is also maintaining international platforms like ***Global Network of Isotopes in Precipitation (GNIP), Global Network of Isotope Rivers (GNIR)*** and ***Global Water Analysis Laboratory (GloWAL) Network*** for empowering the Member States to generate their own chemical, biological and isotopic water data and for providing basic data for the use of isotopes in hydrological investigations within the scope of water resources inventory, planning and development. IAEA and WMO jointly established the GNIP in 1960 to track temporal and spatial variations in oxygen-18 and deuterium in the context of precipitation. GNIR is relatively younger initiative (2002) focused on worldwide data collection, compilation and dissemination of isotopic assays of Earth's river waters. A couple of years ago the 'GloWAL' initiative was launched at the UN 2023 Water Conference, with the aim of establishing global collaboration and communication among Hydrological laboratories for sharing knowledge and promoting capacity building through running training programs. IAEA also encourages its Member States to participate in its technical cooperation program, bilateral cooperation and collaboration with other international organizations, for better understanding the challenges and address them collectively. Needless to say, such multidimensional global approaches are absolutely necessary for strategic planning and holistic management of water resources.

AMONG ALL OTHER INTERVENTIONS,
Isotope techniques in hydrology enhances our understanding of the water cycle at local, regional, and global scales—providing the knowledge needed to meet the targets of SDG 6 and ensure water sustainability for future generations.

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