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Pragyambu

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The purpose of this quarterly digest brought out by the Centre for Ganga River Basin Management and Studies (cGanga) led by the Indian Institute of Technology Kanpur is to disseminate valuable traditional and scientific knowledge assimilated from national and international sources on various aspects of management of water and river restoration and conservation among concerned institutions and citizens.

TREATED USED WATER (SEWAGE): A NEW SOURCE FOR GROUNDWATER RECHARGE AND SUSTAINED RIVER FLOWS

Urban Rivers and the Role of Groundwater

Across the world, rivers flowing through cities are facing severe degradation. Many have dried up, disappeared, or been transformed into polluted drains. Several factors contribute to this situation, including pollution, obstruction of natural drainage pathways, changes in urban land use, encroachments along riverbanks, and the disappearance of wetlands and traditional water bodies.

However, one fundamental factor often overlooked in urban river degradation is the condition of groundwater.

In common perception, rivers and groundwater are treated as separate water sources. Lakes, ponds, rivers, and wells appear to function independently. In reality, they are components of a highly interconnected hydrological system.

When groundwater is excessively extracted, the effects are inevitably reflected in rivers connected to the same aquifer system. Rapid urban growth has significantly increased groundwater extraction for domestic, industrial, and commercial use.

This raises an important question: Is excessive groundwater extraction one of the major drivers behind the degradation of urban rivers?

This issue of *Prgyambu* examines this question from a scientific perspective and explores how groundwater conservation can be integrated into Urban River Management Plans (URMP) and broader District River Management Plans (DRMP).

Before discussing the scientific relationship between rivers and groundwater, a few illustrative examples provide useful insight.

Lessons from Global and Indian Experiences

The Los Angeles River

At the beginning of the twentieth century, rapid urban development in Los Angeles led to extensive groundwater extraction. As groundwater levels declined, the underground geological pathways that previously fed water into the river were disrupted.

Consequently, a river that once flowed throughout the year gradually became seasonal. Today, although water can still be seen within the concrete-lined channel of the Los Angeles River, its natural perennial flow has largely disappeared.

Mexico City's Disappearing Rivers

Historically, Mexico City possessed a well-developed hydrological system consisting of lakes and perennial rivers. However, intensive groundwater extraction during the late twentieth century caused a significant decline in groundwater levels.

Between 1980 and 1990, the groundwater table fell below the riverbeds. As a result, many rivers gradually dried up and disappeared. Their natural channels were replaced by underground drainage systems, and today the city depends heavily on water transported from distant basins.

The Arkavati River in Bengaluru

Bengaluru provides a striking example from India. Today the city depends largely on water transported nearly 100 km from the Cauvery River. Earlier, however, the Arkavati River served as the primary source of water for the city.

Until the 1960s, groundwater levels were high and remained above the riverbed. This ensured a continuous supply of water to the river through baseflow, enabling perennial flow. A reservoir constructed in 1930 regularly remained full, and the river was well connected to the city's extensive network of lakes.

Rapid urban expansion after the 1970s changed this situation. Population growth, urban construction, and increasing water demand led to the drilling of thousands of borewells. Encroachment of lakes and reduced infiltration of rainwater significantly lowered groundwater recharge.

By the 1990s, the groundwater table had declined drastically. The connection between lakes and the river weakened, and many stretches of the Arkavati began to dry up. By 2010, the river had effectively ceased to exist as a flowing system.

Today, Bengaluru frequently experiences severe water shortages during summer—an outcome closely linked to the disruption of the groundwater–river relationship.

Understanding the Surface Water–Groundwater System

These examples demonstrate that declining groundwater levels directly affect river flows.

Water on Earth moves through a continuous cycle involving evaporation, precipitation, runoff, infiltration, and groundwater movement. While rainfall and evaporation are the most visible perceived components of this cycle, groundwater movement and exchange with surface water bodies are equally important.

Rivers and groundwater form parts of a single hydrological system.

Rainwater that infiltrates the soil accumulates in underground geological formations known as aquifers. When groundwater levels are higher than the riverbed, groundwater gradually seeps into the river channel. This process is known as baseflow.

Baseflow is critical during non-monsoon months, when rainfall is absent and rivers depend on groundwater contributions to maintain flow.

However, when groundwater levels decline below the riverbed, this natural seepage stops. Rivers then become dependent only on rainfall or regulated releases from dams. As a result, during dry seasons many rivers shrink drastically and often become carriers of untreated wastewater.

Several Indian urban rivers—including those in Delhi, Indore, Chennai, and Bengaluru—show evidence of this phenomenon.

Role of Groundwater in Sustaining Large Rivers

Groundwater contributions are not limited to small urban rivers. They also play an important role in maintaining the flows of large river systems.

Research from the Department of Earth Sciences at IIT Roorkee highlights that when the Ganga descends from the Himalayas into the plains, groundwater interactions become an important contributor to river flow.

Major tributaries such as the Ghaghara, Gandak, and Yamuna carry both surface runoff and groundwater contributions from their respective basins. These tributaries sustain the flow of the Ganga across the plains before merging into the main river.

Thus, groundwater processes are integral to the hydrology of both small and large river systems.

Integrating Treated Used Water into River Restoration

At present, India is preparing District River Management Plans (DRMP), including Urban River Management Plans (URMP) and Rural River Management Plans (RRMP).

This provides a timely opportunity to integrate groundwater conservation with river restoration.

Simultaneously, many Sewage Treatment Plants (STPs) are being constructed under programmes such as Namami Gange, the Smart Cities Mission, and AMRUT.

The water reaching these STPs is used water that originally came from natural water sources. From the perspective of long-term sustainability, this water should ideally be returned to the local hydrological system after treatment.

A particularly effective strategy is to direct treated water toward local lakes, ponds, wetlands, and traditional water structures. This can simultaneously restore surface water bodies, recharge groundwater, and strengthen local ecosystems.

Priority Use of Treated Sewage

Several proposals are often made regarding reuse of treated wastewater, including supply for toilet flushing in residential areas or industrial applications.

However, such uses require extensive infrastructure, dual distribution networks, and significant energy expenditure to achieve high treatment standards.

A more sustainable and cost-effective approach is to prioritize local ecological restoration.

The most valuable use of treated sewage lies in the direct restoration of local surface water bodies and the indirect recharge of groundwater.

When treated water is conveyed to lakes, ponds, or wetlands:

- water bodies are rejuvenated
- the treated water undergoes further polishing through nature-based systems
- groundwater recharge increases
- natural drainage pathways are restored, reducing urban flooding
- biodiversity and ecosystem health improve

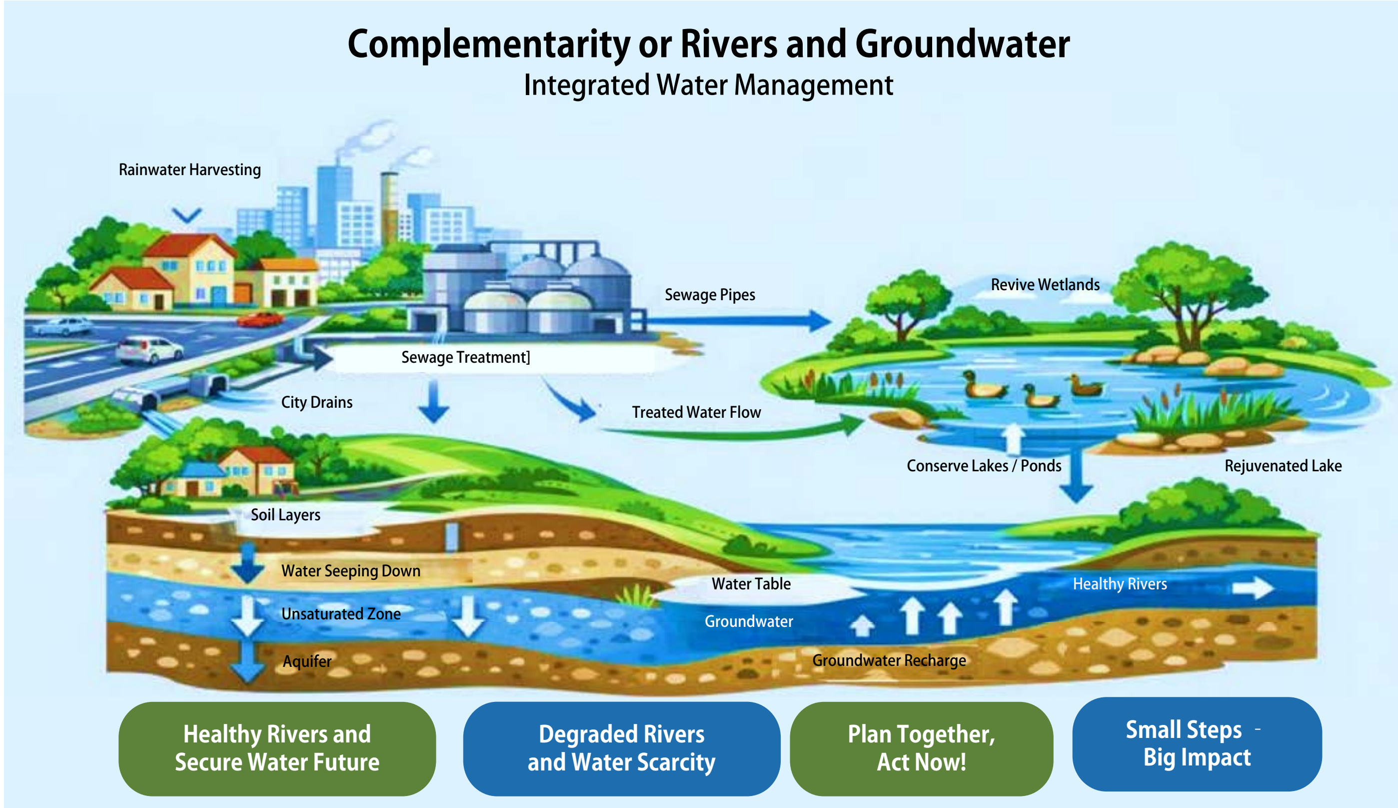

Figure: Interaction between Surface Water, Groundwater, and Treated Used Water

Reviving traditional channels that historically connected water bodies can also help transport both treated water and rainwater.

Economic and Energy Considerations

Some countries treat wastewater to extremely high standards, even making it potable. While such technologies are available, they require substantial energy and financial investment.

In a developing country context, it is important to evaluate such solutions carefully from both economic and energy perspectives.

Nature itself provides an efficient and cost-effective purification mechanism. As water percolates through soil layers and aquifers, it undergoes natural filtration and purification.

Using natural systems such as aquifers, wetlands, and lakes for water storage and purification can therefore be a highly sustainable alternative.

Enabling Year-Round Groundwater Recharge

Many groundwater conservation initiatives—such as the "Catch the Rain" campaign—focus on capturing rainfall during the monsoon.

While valuable, these initiatives depend largely on seasonal rainfall.

Treated wastewater offers the possibility of year-round groundwater recharge.

Experiments in Bengaluru have demonstrated that directing treated water from STPs into lakes and ponds can successfully recharge groundwater and improve local water availability.

Such decentralized systems also reduce energy requirements and infrastructure costs.

Nature-Based Systems for Additional Treatment

Innovative solutions can also be developed under URMP and RRMP frameworks.

One promising approach involves routing treated water through constructed or natural wetlands before it enters rivers or lakes.

Wetlands act as natural filters and storage systems. They can:

- improve water quality through biological processes
- support biodiversity
- store water during floods
- release water gradually during dry periods

Depending on local geography, land availability, and proximity to STPs, such systems can be integrated into city-level water management strategies.

Measures for Strengthening Groundwater and River Systems

To restore groundwater levels and sustain river flows, the following actions are recommended:

1. Identify, demarcate, and protect all remaining surface water bodies such as ponds, lakes, and tanks.

2. Preserve traditional water structures including wells, stepwells, and small streams.
3. Install recharge pits in large open spaces such as parks, stadiums, and temple complexes.
4. Construct recharge wells in areas where groundwater levels are very low.
5. Promote public participation in rainwater harvesting initiatives.
6. Ensure proper maintenance and management of seasonal drainage channels.
7. Connect rainwater drains to recharge structures and urban ponds.
8. Prepare location-specific water management plans based on local geography, soil chemistry, and biodiversity considerations.

Rivers and Groundwater must be Managed Together

River conservation cannot succeed through surface water management alone. Groundwater conservation and recharge are equally essential.

Only through integrated management—including rainwater harvesting, protection of lakes and ponds, and sustainable groundwater use—can the natural relationship between rivers and aquifers be restored.

Rivers and groundwater are complementary components of a single hydrological system. If groundwater is depleted, rivers will inevitably dry up, leading to serious ecological and socio-economic consequences.

However, with thoughtful planning and coordinated action, even small interventions can lead to significant improvements in water security and river health.

This schematic illustrates the natural interaction between surface water bodies (lakes, ponds, and rivers) and groundwater stored in aquifers. Rainwater and surface water gradually infiltrate through soil layers into the unsaturated zone and recharge the aquifer. When the groundwater table lies above the riverbed, groundwater flows into rivers through baseflow, helping sustain river flows during non-monsoon periods.

In urban areas, treated used water (sewage) from Sewage Treatment Plants (STPs) can be directed to lakes, ponds, or wetlands. These water bodies enable further polishing through nature-based processes, support ecosystems, and facilitate groundwater recharge, which in turn helps maintain river flows and strengthens the overall hydrological system.

HIGHLIGHT PULL-QUOTES

PULL-QUOTE 1 "Rivers and groundwater are not separate water sources; they are parts of a single interconnected hydrological system."

PULL-QUOTE 2 "When groundwater levels fall below the riverbed, baseflow stops—and rivers begin to dry."

PULL-QUOTE 3 "The most valuable use of treated sewage lies in restoring local water bodies and indirectly recharging groundwater."

PULL-QUOTE 4 "Reviving lakes and ponds not only restores water storage but also strengthens ecosystems and biodiversity."

PULL-QUOTE 5 "Nature-based systems such as wetlands can further polish treated water while supporting groundwater recharge."

PULL-QUOTE 6 "Without conserving groundwater, it is not possible to keep rivers alive."

PULL-QUOTE 7 "Small interventions—reviving ponds, reconnecting drains, and using treated water—can bring large improvements in river health."

PULL-QUOTE 8 "Treated used water offers a year-round opportunity for groundwater recharge, unlike rainwater which is seasonal."

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