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A New Perspective on Wastewater Reuse in India: Prioritizing Ecosystem Restoration over Direct Agricultural Use

[From the Perspectives of Public Health, Environment, Economy, Energy, and Sustainable Development]

In the previous issue, we discussed the theme "Treated Used Water (Sewage): A New Source for Groundwater Recharge and Sustainable River Flows", focusing on urban rivers, groundwater systems, surface water–groundwater interactions, and the potential of treated wastewater reuse.

Through examples such as the declining rivers of Mexico City and the Arkavathi River in Bengaluru, it became evident how unplanned urbanization, excessive groundwater extraction, and inadequate water management practices are impacting river systems. At the same time, we explored how concepts such as treated sewage reuse, nature-based treatment systems, and year-round groundwater recharge can contribute towards integrated and sustainable management of rivers and groundwater resources.

Continuing this dialogue, this issue explores the global perspective of viewing "wastewater as a resource" and examines its potential role in strengthening water security and supporting river restoration efforts in India.

The Global Shift: Wastewater to Resource

Countries such as Singapore, Israel, Australia, and the United States have recognized treated wastewater as a valuable resource rather than a waste product. Singapore's "NEWater programme" and Israel's "Soil Aquifer Treatment (SAT) system" demonstrate how scientifically treated wastewater can be integrated into agricultural, industrial, and even potable water systems. These successful examples have shown the world that addressing water scarcity is not only about finding new sources of water, but also about recycling and efficiently managing available water resources.

In India, with the growing importance of the 'Circular Water Economy' approach, increasing emphasis is being placed on wastewater treatment and reuse. India generates more than '72,000 MLD (Million Litres per Day)' of sewage every day, which has significant potential to contribute towards groundwater recharge, industrial water requirements, and addressing urban water challenges.

India's water challenge is not only about water availability, but also about effective water management. Therefore, strategies for treated wastewater utilization must be developed according to Indian conditions, ecological requirements, and long-term sustainability goals.

Thus, the "Wastewater to Resource" model is emerging as an important pathway towards future sustainable water security. However, the question remains—Is the same model directly suitable for India?

PARAMETER	INDIA	ISRAEL	SINGAPORE
AREA (sq. km)	3,287,000	22,000	735
ANNUAL RAINFALL (BCM)	~4,000	~10	~1.7
ANNUAL WATER USE (BCM)	~750	~2.5	~0.8
WASTEWATER REUSE (%)	~3–8%	~90%	~40–50%
SHARE OF IRRIGATION FROM REUSED WATER	2%	~50%	N/A
ENERGY CONSUMPTION PER CUBIC METER (kWh/m³)	~0.2	~1.2	~1.0–1.5

A direct comparison between India and countries such as Israel, Singapore, or other developed nations is neither scientifically appropriate nor practically feasible. The reason behind this is that the water-related conditions, geographical characteristics, agricultural systems, socio-economic structures, institutional capacities, energy availability, public health challenges, and administrative and regulatory frameworks of these countries differ significantly from those of India. India is a country with an extensive river

network, monsoon-driven rainfall patterns, and diverse ecological regions.

For example, India receives an average annual rainfall of nearly 4,000 billion cubic metres (BCM), whereas Israel receives approximately 10 BCM and Singapore only about 1.7 BCM. Similarly, India's annual water use is around 750 BCM, while Israel uses approximately 2.5 BCM and Singapore around 0.8 BCM. These figures clearly indicate that India's challenge is not an absolute lack of water at the national level, but rather the effective management of its water resources.

The major challenges faced by India include the highly seasonal nature of rainfall, spatial imbalance in water availability, increasing groundwater extraction, water pollution, degradation of rivers and water bodies, limited wastewater treatment capacity, and declining ecological functions of natural systems.

Therefore, water management strategies for India must be developed in accordance with its own geographical realities, social conditions, and ecological requirements rather than adopting models directly from other countries.

Careful Interpretation of International Examples: A Comparative Water Perspective

Optimal Use of Treated Wastewater: Agriculture, Industry, or Living Rivers?

The fundamental question before us is not whether treated wastewater should be reused, but rather what its most appropriate and beneficial use should be under Indian conditions. Should it be viewed only as an alternative water source, or should it also be considered as a means for the restoration of rivers, water bodies, wetlands, and groundwater systems? Ultimately, we must determine which application of treated wastewater provides the greatest long-term social, ecological, economic, and environmental benefits. This question will play a crucial role in shaping the future direction of water management in India.

Countries such as Israel and Singapore have developed their wastewater reuse policies under conditions of extreme water scarcity, where maximizing the use of every drop of water is a national necessity. India's situation is significantly different.

India receives nearly 400 times more rainfall than Israel and possesses extensive river networks, floodplains, wetlands, and diverse ecological systems. Therefore, in the Indian context, treated wastewater should not be viewed merely as an alternative water source or only as a means of water recovery.

India's wastewater reuse strategy needs to adopt a much broader vision—one that not only enhances water availability but also supports the revival of declining rivers, particularly seasonal and rain-fed rivers, restores wetlands and water bodies, strengthens groundwater recharge, and improves the functioning of natural hydrological and ecological systems.

Treated wastewater is not merely water that can be reused; it can also serve as an important tool for the rejuvenation of rivers, groundwater systems, and ecological ecosystems. In the Indian context, the key consideration is where its most beneficial use lies—whether in agriculture and industries, or in restoring and strengthening living rivers and natural ecosystems.

In other words, the objective of treated wastewater management in India should not be limited to water reuse alone; it should also focus on reconnecting the

broken relationship between water, nature, and ecosystems.

Drying Rivers and Declining Ecological Balance: A Critical Challenge in the Indian Context

India has traditionally been known as the land of rivers. Along with major rivers, the country has thousands of smaller rivers, streams, and tributaries that collectively form the lifeline of river systems. However, over the past few decades, many of these smaller rivers and seasonal streams have started remaining dry for most of the year. Several rivers now flow only during a few months of the monsoon season, while their existence almost disappears during the remaining period. This decline affects groundwater recharge, aquatic biodiversity, and the natural base flow that supports larger rivers.

The impact of this situation is not limited to rivers alone. When the flow of a river declines, the entire connected ecosystem is affected. Groundwater reserves associated with river systems receive less recharge, leading to declining water levels in wells, hand pumps, and tube wells. Aquatic species such as fish, aquatic plants, amphibians, and other forms of biodiversity dependent on river ecosystems are also affected. At the same time, the natural **base flow** received by larger rivers decreases, which is essential for maintaining river health during dry seasons.

According to the **Central Ground Water Board (CGWB)**, nearly **60% of irrigation requirements and 85% of rural drinking water needs in India depend on groundwater**, while groundwater levels continue to decline in many regions. Similarly, the **NITI Aayog Composite Water Management Index (2018)** highlighted that several parts of the country are moving towards severe water stress. This situation is not merely a question of water availability; it is also a consequence of the weakening natural relationship between rivers and groundwater.

From an Indian hydrological perspective, rivers and groundwater are deeply interconnected. During dry seasons, the flow of many rivers is not maintained by rainfall but by groundwater-supported base flow. Therefore, when rivers dry up, groundwater systems are affected, and when groundwater levels decline, river flows become weaker. This creates a **vicious cycle** that further threatens long-term water security and ecological balance.

The renowned environmentalist Aldo Leopold once said:
"To keep every cog and wheel is the first precaution of intelligent tinkering."

"While scientifically and technologically it may be plaussible to convert sewage and trade effluents into usable water for any beneficial use, the key question is whether it would be sustainable? Closing the water loop at appropriate spatio-temporal scale and converting rapid flow into slugish flow is perhaps more suitable for wate based circular economy and water security in India"

Under such circumstances, treated wastewater emerges as a new opportunity. If a significant proportion of treated wastewater, meeting scientific quality standards, is directed towards the rejuvenation of small rivers, streams, wetlands, and degraded water bodies, it can help maintain minimum ecological flows throughout the year. This would not only support local groundwater recharge and biodiversity conservation but also strengthen the base flow contribution to larger river systems. From

this perspective, treated wastewater use should not be viewed merely as water reuse, but as a means of ecological restoration and river rejuvenation.

In the Indian context, this perspective reminds us that small rivers, streams, and wetlands are equally important "components" of the larger water system. Neglecting these elements ultimately weakens the entire river network and overall water security. Therefore, treated wastewater should not be utilized only for consumption-oriented purposes, but also as a resource for restoring and strengthening these ecological systems. This approach can become an important step towards achieving long-term water security, biodiversity conservation, and sustainable development in India.

In this issue, we have attempted to view treated wastewater not only as a reusable water source but also as a potential tool for river rejuvenation, groundwater recharge, and ecological restoration. However, several important dimensions of this subject require deeper exploration and discussion.

In the upcoming issue, we will examine this question from multiple perspectives, including its impacts on public health, soil health, environment, energy consumption, and the economy. We will explore whether the benefits of treated wastewater reuse remain limited to specific users or whether they extend to society and ecosystems as a whole. The next issue will provide a detailed analysis of the benefits, challenges, limitations, and potential risks associated with treated wastewater utilization in the Indian context.

It is hoped that this discussion will contribute towards developing an Indian perspective on treated wastewater management—one that strengthens not only water security but also ecological balance, social well-being, and the goals of sustainable development.

"Slowing down the movement of rainwater after it reaches the Earth is the foundation of future water security"