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# Reusing Wastewater for Watering: An Approach to Urban Water Resilience

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**Abstract**.

The Urban areas are most vulnerable to water shortages as a result of the rising population rapid urbanization and the impact of climate change. The freshwater resources that are traditionally available do not provide for the requirements of families and also protect the integrity of urban green spaces which are crucial to healthy development of the area and the surrounding environment. Recycling treated wastewater is an ideal option to increase the resilience of water systems in cities and also promote sustainable water management methods. This article examines the possibility of recycling wastewater treated to improve irrigation practices as an essential element of water infrastructures that can stand up to the challenges of living in urban areas. The article discusses the most recent innovations in wastewater treatment and demonstrates their ability to be in line with standards for water quality and to reduce the discharge of contaminants into the environment. Beyond technical aspects this research reveals that efficiency of energy usage and environmental performance. The research shows that addressing the issue of wastewater reuse could drastically reduce the stress on the water resources which are traditional and enhance the reliability of water supply. It can also help in the creation of circular strategies for managing water. When it's integrated with organizations that are cohesion-based and supported with transparent communication and stakeholder participation Reusing wastewater is an effective way to increase your resilience to urban water systems.

**Keywords**. wastewater reuse, urban water resilience, irrigation, sustainable water management, treated wastewater

## 1. Introduction

Water systems in urban areas are being threatened by the effects of rapid urbanization as well as population growth and the increasing impact of the climate-related variability of hydrological systems[1]. In many urban areas traditional freshwater resources aren't enough to meet the needs of households, economic activities as well as the care of urban green spaces that are crucial for microclimate control as well as for biodiversity conservation and overall well-being of the public[2]. Cities are forced to rethink the traditional methods of water management and consider alternatives that are more sustainable alternatives. In this context the reuse of treated wastewater is receiving a lot of interest as a crucial aspect to sustainable management of urban waters[3]. In addition to being viewed as a waste item, treated effluent has been considered a resource that can be a major contributor to diversification of water supply. If properly managed and treated the reclaimed water supply is an affordable and local source that is less prone to changes in the climate, especially for non-potable uses such as watering urban green areas[4]. This is in line with the circular economy concept which is focused on preserving resources and reducing environmental pollution in addition to an increase in efficiency of using water[5]. However, integrating recycled waste into water systems that is made for use in urban areas is a difficult procedure that extends beyond the capabilities of the technology. The effectiveness of current techniques for treatment needs to be evaluated in conjunction with their energy use as well as the environmental impact and sustainability of their operations. Additionally, the capacity of the institution as well as their acceptance by the public and the reliability of the system of regulation have significant influence on the effectiveness of recycling programs. Dependence on

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recycled water's quality that is backed by an effective and clear governance system as well having a robust monitoring system is vital in the process implementation. In addition, regulators must to protect the individuals without compromising efficiency. This paper examines the impact recycling treated wastewater into resilient urban water and focuses on irrigation strategies in urban areas[6]. Through synthesis of recent research findings concerning environmental, technical social, and governance facets this study examines the conditions in the conditions that wastewater reuse can be successfully integrated into water-related strategies for urban resilience. With this holistic approach this paper aids in the transition away from linear water management models to more adaptive circular systems that can be used to dealing with future and present water-related demands[7].

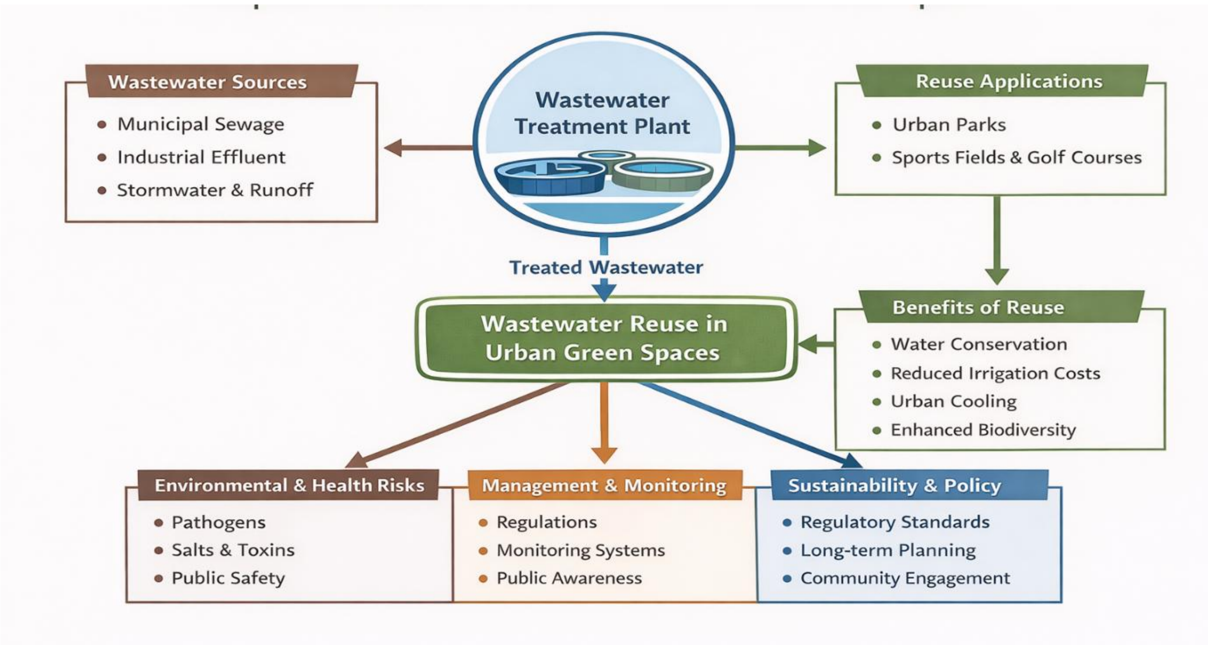


**Fig. 1.** Conceptual framework of wastewater reuse for urban green spaces.

## 2. Urban Water Resilience and Wastewater Reuse

The resistance of cities to the urban resilience of water resilience to water (is described as the ability for urban structures to deal with the stresses and shocks that result from water-related issues) more and more relies on transitioning towards a circular instead of a linear framework for managing resources[8]. As a result, water reuse is an essential solution to ensure stable and drought-resistant water resources while also allowing diversification of supply and reducing pollution to the environment (**Table 1**). However, its implementation is not just about technology and presents a variety of issues in the areas of governance, public perception and economic value aspects[9]. To ensure that integration is successful it is essential to have strict and deliberate treatment strategies are needed flexible regulatory frameworks that effectively manage the risks associated with newly discovered pathogens, CECs and active public involvement in order to gain a social licence[10]. The end result is that it's an urban system of water which wastewater reuse is integrated, and which must ensure water security, conservation of resources and protection of ecosystems as a unified approach in order to safeguard the capacity to adapt to urbanization and climate change[11].

**Table 1.** Key benefits of wastewater reuse for urban water resilience.

| Aspect | Benefit |
|---|---|
| **Water Supply** | An alternative source of water that is reliable in times of drought |
| **Environment** | Reduction of effluent discharges and pollution |
| **Economy** | Lower demand for freshwater and cost savings |
| **Social** | Promotes maintenance of green spaces and well-being of the public. |

## 3. Social and Governance Challenges

The Reuse of wastewater is an essential strategy to improve your water's resilience of urban areas[12]. It provides a local, reliable drinking water source that is not impacted by of climate fluctuations, it instantly increases the redundancy of cities and protects them from the effects of droughts and supply shocks[13]. Additionally, it increases the flexibility in the water portfolio for urban use by allowing managers to assign various streams of superior quality for certain non-potable applications (such to cool industrial processes or irrigation) which decreases the dependence for potable resources, and also ensures that the highest quality sources are readily available to meet the requirements for the urban area[14]. Furthermore, to reducing the release of waste into the surrounding environment and decreasing the environmental risk caused by pollution to ecosystems which act like natural water buffers, the method of circularity could also enhance the ability to adapt (**Table 2**).

**Table 2.** Governance and social factors that affect the adoption of reused wastewater

| Factor | Description |
|---|---|
| **Public Acceptance** | Perception, awareness and attitudes to behavior |
| **Policy & Regulation** | Legal Standards, protocols for monitoring |
| **Stakeholder Engagement** | Coordination between utilities, municipalities and localities |
| **Economic Incentives** | Subsidies, financing or cost savings |

## 4. Limitations and Future Perspectives

Despite its well-known advantages, the process of recycling treated wastewater is not without its challenges. numerous structural issues that have to be addressed to ensure long-term sustainability[15]. Advanced treatment methods usually require significant energy consumption as well as operating expenses that can restrict the use of large-scale facilities, especially in urban environments that have scarce resources (**Table 3**).

**Table 3.** Key limitations and future directions for treated wastewater reuse in urban systems

| Aspect | Identified limitations | Future perspectives and improvement pathways |
|---|---|---|
| **Treatment technologies** | The high energy demands of modern processes and complicated operation | The optimization of the treatment lines Integration of low-energy and natural solutions |
| **Energy consumption** | reliance on conventional energy sources can increase operating costs | Combining wastewater reuse and renewable energy resources like biogas or solar power |
| **Water quality variability** | Variations in the composition of influents and the presence of new contaminants | Continuous monitoring in real-time |
| **Environmental footprint** | The generation of residual streams, like concentrates and sludge | Better management of residuals along with life-cycle assessments-based optimization |
| **Regulatory framework** | Limited flexibility and fragmented regulations across regions | The development of harmonized, appropriate and flexible regulatory frameworks |
| **Social acceptance** | Public perception and a lack of trust in the use of reclaimed water | Stakeholder involvement, transparent communication and awareness campaigns |

| | | |
|---|---|---|
| **Institutional capacity** | Insufficient coordination among urban stakeholders | Improved interdisciplinary collaboration and models of integrated governance |

## 5. Conclusion

Reusing treated water to supply urban irrigation is an efficient way to improve the resilience of water systems in urban areas in the midst of rising temperatures and extreme drought. Through the transformation of waste water as an inert product into a valuable resource urban water system can reduce their dependence on freshwater sources and assist in the preservation of green spaces that improve the environment's quality and the well-being of the entire community. This study has shown that the advantages of water reuse extend beyond the improvement of the supply of water. Reuse that is well-designed and managed can help decrease the volume of pollutants discharged and improve the control of the resources used in a sustainable fashion and enhance the capacity of cities to adjust to the impacts of the stress caused by hydrological. Modern treatment technology has proven its ability to comply with strict standards for quality when it comes to the cases of applications not potable but their energy use and environmental footprint requires careful planning to ensure the long-term sustainability of. Coordination between institutions on social acceptance and a uniform regulatory framework are crucial for ensuring the sustainability and sustainability of attempts to reuse the water. Transparent governance, strong monitoring systems, and efficient participation of stakeholders are vital to building trust with the public, and in ensuring this process remains safe and reliable. Re-use of treated wastewater is an important component of urban strategies for managing water.

## References

[1] A. E. Awode, J. R. Adewumi, O. Obiora-Okeke, et A. A. Komolafe, « Evaluation of hydrological impacts of urbanization and climate change: integrating SWAT for adaptive water management in South-Western Nigeria », *Int. J. River Basin Manag.*, vol. 0, n° 0, p. 1-13, juill. 2025, doi: 10.1080/15715124.2025.2531540.

[2] S. Kameswaran, B. Ramesh, et M. Bangeppagari, « Environmental Conservation for Rural and Urban Development », in *Prospects for Soil Regeneration and Its Impact on Environmental Protection*, S. A. Aransiola, B. R. Babaniyi, A. B. Aransiola, et N. R. Maddela, Éd., Cham: Springer Nature Switzerland, 2024, p. 47-71. doi: 10.1007/978-3-031-53270-2_3.

[3] S. M. Michalopoulos et I. K. Kalavrouziotis, « Treated wastewater reuse practices, under a holistic approach at the city scale », *Oper. Res.*, vol. 25, n° 3, p. 65, juin 2025, doi: 10.1007/s12351-025-00937-x.

[4] I. Bencheikh, J. Mabrouki, K. Azoulay, A. Moufti, et S. El Hajjaji, « Predictive analytics and optimization of wastewater treatment efficiency using statistic approach », in *Big data and networks technologies 3*, Springer, 2020, p. 310-319.

[5] M. Yang *et al.*, « Circular economy strategies for combating climate change and other environmental issues », *Environ. Chem. Lett.*, vol. 21, n° 1, p. 55-80, févr. 2023, doi: 10.1007/s10311-022-01499-6.

[6] H. Charkaoui, D. Azdem, J. Mabrouki, et S. EL Hajjaji, « Moroccan Bentonite as a Sustainable Adsorbent: Preparation, Purification, Na-Activation, and Structure–Property Relationships for Organic Pollutant Remediation », *ChemistrySelect*, vol. 10, n° 42, 2025, doi: 10.1002/slct.202504647.

[7] J. Mabrouki, M. Azrour, A. Boubekraoui, et S. El Hajjaji, « Simulation and optimization of solar domestic hot water systems », *Int. J. Soc. Ecol. Sustain. Dev. IJSESD*, vol. 13, n° 1, p. 1-11, 2022.

[8] F. Asghari *et al.*, « Resilience Assessment in Urban Water Infrastructure: A Critical Review of Approaches, Strategies and Applications », *Sustainability*, vol. 15, nº 14, p. 11151, janv. 2023, doi: 10.3390/su151411151.
[9] A. Fatni *et al.*, « Characterization and mitigation strategies for inorganic scaling in reverse osmosis system treating brackish groundwater », *Sustain. Chem. One World*, vol. 5, p. 100035, mars 2025, doi: 10.1016/j.scowo.2024.100035.
[10] P. Supriya, « Urban Water Management and Climate Change Mitigation: A Review for Chennai City », *EcoTech Urban. Pioneer. Sustain. Technol. Dev. Cities*, p. 45, 2025.
[11] Solomon E. Shaibu, Peter O. Adigun, et Nnamso D. Ibuotenang, « Sustainable Urban Water Management: Reuse, Recycling and Climate-Resilient Strategies », *Int. J. Sci. Res. Sci. Eng. Technol.*, vol. 12, nº 1, p. 122-135, janv. 2025, doi: 10.32628/IJSRSET251217.
[12] A. G. Capodaglio, « Urban Water Supply Sustainability and Resilience under Climate Variability: Innovative Paradigms, Approaches and Technologies », *ACS EST Water*, vol. 4, nº 12, p. 5185-5206, déc. 2024, doi: 10.1021/acsestwater.4c00203.
[13] D. Azdem, J. Mabrouki, A. Moufti, et A. Fatni, « Assessment of heavy metal contamination in seawater in Agadir coastline, Morocco », *Desalination Water Treat.*, p. 100129, 2024.
[14] S. R. Pokhrel, G. Chhipi-Shrestha, K. Hewage, et R. Sadiq, « Sustainable, resilient, and reliable urban water systems: making the case for a “one water” approach », *Environ. Rev.*, vol. 30, nº 1, p. 10-29, mars 2022, doi: 10.1139/er-2020-0090.
[15] J. Maura, S. Atreya, et A. Arshi, « The Treatment of Wastewater, Recycling and Reuse - Past, Present, and in the Future », *Int. J. Sci. Res. IJSR*, vol. 12, nº 11, p. 210-222, nov. 2023, doi: 10.21275/SR231013064713.