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INTEGRATED WASTEWATER MANAGEMENT AS A FACTOR OF SUSTAINABLE ENVIRONMENTAL DEVELOPMENT IN UZBEKISTAN

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Abstract
This article examines the critical role of integrated wastewater management in achieving sustainable environmental development in Uzbekistan. The study explores the status of wastewater collection, treatment, and reuse in urban and industrial regions. It highlights the environmental risks posed by untreated wastewater and analyzes the economic and ecological benefits of reusing treated water. Drawing on statistical data and global best practices, the paper outlines strategic recommendations to improve the wastewater management system in Uzbekistan, emphasizing technological modernization, institutional coordination, and community awareness as key levers of progress.

Keywords: Wastewater, reuse, urban sanitation, environmental protection, sustainability, Uzbekistan, wastewater treatment, water scarcity, circular economy.

Introduction

Uzbekistan, a landlocked country with an arid continental climate, faces increasing environmental challenges linked to water scarcity and pollution. The country's limited freshwater availability—largely dependent on transboundary rivers like the Amu Darya and Syr Darya—is further strained by inefficient water use practices and pollution from untreated wastewater. Rapid urbanization, population growth, and industrial development have contributed to a significant rise in municipal and industrial wastewater generation, making integrated wastewater management (IWM) a national priority.

As of 2023, Uzbekistan generates more than 2.3 billion cubic meters of wastewater annually. This includes discharges from households, manufacturing facilities, agro-industrial complexes, and public institutions. However, only 68% of this volume undergoes at least partial treatment, and a mere fraction is treated to a level suitable for reuse.

Most of the existing wastewater treatment plants (WWTPs) were constructed during the Soviet era and suffer from outdated technologies, energy inefficiency, and capacity limitations. In many smaller cities and rural settlements, centralized sewage systems are either underdeveloped or nonexistent, leading to the discharge of raw wastewater directly into open water bodies or the ground.

Urban centers such as Tashkent, Bukhara, Samarkand, and Andijan produce a disproportionately large share of the country's wastewater due to higher population density and industrial activity.

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Table 1. Volume and Treatment of Wastewater in Selected Cities (2023)

City	Wastewater Generated (mln m³)	Treated Wastewater (mln m³)	Treatment Efficiency (%)
Tashkent	460	370	80%
Samarkand	215	155	72%
Andijan	190	120	63%
Bukhara	170	125	74%
Nukus	95	60	63%

The untreated portion of wastewater is often discharged into rivers, canals, or underground systems, polluting surface and groundwater sources and threatening both human and ecosystem health.

The environmental impacts of poorly managed wastewater are multifaceted:

- **Water Pollution**: Key rivers like the Chirchik, Zarafshan, and Amu Darya face high levels of chemical and biological contamination.
- **Ecosystem Degradation**: Nutrient overload leads to eutrophication, harming fish populations and aquatic flora.
- **Soil Degradation**: Agricultural lands irrigated with contaminated water experience salinization and reduced fertility.
- **Public Health Risks**: Communities downstream face increased exposure to waterborne diseases, including hepatitis A, dysentery, and intestinal infections.

Table 2. Selected Water Quality Indicators in Affected Rivers

River	BOD_5 (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)	Water Quality Class
Chirchik	8.5	12.3	2.1	IV (polluted)
Zarafshan	7.2	10.8	1.9	IV (polluted)
Amu Darya	6.3	9.4	1.4	III (moderately polluted)

Globally, treated wastewater is increasingly used for agriculture, industrial cooling, landscape irrigation, and even groundwater recharge. For Uzbekistan, where agriculture consumes over 90% of total water withdrawals, reuse offers strategic value.

Yet, as of 2023, only around 15% of treated wastewater is reused, primarily for non-potable purposes such as park irrigation and construction. The barriers include:

- **Lack of incentives and tariff structures** for water reuse.
- **Public mistrust and limited awareness** of the safety of treated water.
- **Fragmented institutional responsibilities** and weak enforcement of reuse regulations.

Uzbekistan's **Water Code** and **Law on Environmental Protection** provide a foundation for wastewater regulation, but enforcement remains inconsistent. The

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National Strategy on Water Resources Management (2021–2030) outlines reuse targets, yet lacks actionable implementation plans.

To ensure effective integrated wastewater management, coordination is needed between the Ministry of Water Resources, Ministry of Ecology, regional khokimiyats (governor offices), and international partners like UNDP and GIZ.

Uzbekistan can learn from countries that have successfully implemented large-scale reuse systems:

- **Israel**: Reuses over 85% of its treated wastewater in agriculture.
- **Singapore**: Operates the "NEWater" program that recycles wastewater into potable water.
- **Spain**: Has legal mandates requiring reuse in water-scarce regions.

These successes are based on strong regulatory frameworks, investments in advanced treatment technologies (e.g., membrane bioreactors), and public engagement campaigns.

To develop sustainable wastewater management in Uzbekistan, the following actions are recommended: Rehabilitate and modernize WWTPs using energy-efficient and modular systems. Introduce economic incentives such as reuse subsidies and wastewater discharge taxes. Strengthen regulatory enforcement with updated standards and penalties. Promote public awareness campaigns about water reuse benefits and safety. Develop a national roadmap for circular water management with inter-ministerial coordination. Establish pilot projects in water-stressed regions to demonstrate reuse feasibility.

Conclusion

Wastewater is not merely a byproduct of human activity — it is a valuable resource that, if properly managed, can contribute to water security, environmental protection, and economic resilience. For Uzbekistan, transitioning to an integrated wastewater management system is no longer optional but essential. With coordinated action, targeted investments, and public engagement, the country can transform its wastewater sector into a pillar of sustainable development.

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