

**Short Communication**

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Energy Recovery from Falling Greywater in High-Rise Buildings

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Received Date: March 09, 2026**Published Date: March 26, 2026****Introduction****Water Scarcity and Greywater Reuse**

Water scarcity is one of the most significant global challenges, particularly in arid and semi-arid regions, and it is increasingly affecting large urban centres worldwide. Rapid population growth, urbanization, and climate change are intensifying pressure on freshwater resources. The expansion of megacities has increased demand for water supply, wastewater treatment, and energy resources. At the same time, rising energy costs and limited freshwater availability highlight the need for alternative and sustainable water management solutions.

One widely discussed approach is the reuse of treated wastewater, especially for agricultural irrigation. This strategy allows high-quality freshwater to be reserved for drinking purposes while reducing the burden on water distribution systems. With global urban populations expected to increase significantly in the coming decades, sustainable water management strategies will become increasingly important. Household wastewater is typically divided into two main categories: blackwater and greywater (GW). Blackwater contains toilet waste and organic residues from kitchen sinks and dishwashers. In contrast, greywater originates from showers, bathroom sinks, and laundry machine.

Falling GW reuse in high-rise buildings (HRB) has been implemented in several countries worldwide. For example, Australia provides incentives for installing greywater systems, while many U.S. states encourage residential greywater reuse. Countries such

as Japan, Spain, Korea, China, Cyprus, and Israel have also adopted policies or regulations promoting greywater recycling in buildings and urban areas. These initiatives demonstrate the growing recognition of greywater as a valuable water resource.

High-Rise Buildings

High-rise buildings are increasingly common in densely populated urban environments where land availability is limited. Typically defined as buildings with more than twenty floors, these structures can reach heights between 75 and 175 meters, depending on floor height and design. Major cities worldwide contain thousands of such buildings, reflecting the ongoing trend toward vertical urban development.

Turbine Technology for Energy Generation

Turbines are mechanical devices that convert the kinetic and potential energy of flowing water into electrical energy. Several types of turbines exist, including Crossflow, Francis, Kaplan, Pelton, and Turbo turbines. The choice of turbine depends on factors such as flow rate and hydraulic head. The power generated by a turbine can be expressed as:

$$P_a = \eta \cdot g \cdot \rho \cdot q \cdot H$$

where P_a is the generated energy, η is the turbine efficiency (typically around 70%), g is gravitational acceleration, ρ is water density, q is flow rate, and H is the water head. Energy production

therefore depends primarily on the flow rate of greywater and the vertical height difference within the building.

Risks and Challenges of Greywater Reuse

Despite its potential benefits, greywater reuse must be carefully managed due to potential health and environmental risks. Greywater may contain small quantities of pathogens, detergents, oils, nutrients, and suspended solids. These contaminants can affect soil structure, irrigation systems, and groundwater quality if not properly treated. Health risks can be minimized by avoiding direct human contact with greywater and by applying appropriate treatment methods, including filtration and disinfection. Additionally, effective management systems are required to ensure proper operation and maintenance of greywater reuse systems.

Public acceptance is another crucial factor influencing greywater implementation. Social perceptions of risk, regulatory frameworks, and economic incentives all play a role in determining the adoption of greywater technologies. Governance models must therefore consider technical, economic, and social aspects to ensure sustainable operation.

Energy Recovery from Greywater

The proposed system involves separating greywater from other wastewater streams within high-rise buildings. Greywater from showers, bathroom sinks, and washing machines is collected through a dedicated drainage network. After basic treatment and disinfection, the greywater is stored in collection tanks located at a designated elevation within the building.

From the storage tank, greywater flows downward by gravity through pipes connected to turbines installed at various levels in the building. The vertical height difference between the tank and the turbine provides the hydraulic head required for energy generation. The turbines are connected to generators that convert mechanical energy into electricity, with an overall efficiency of approximately 70%. Electricity generated from the system can be used directly within the building or supplied to the national power grid. Following energy recovery, the treated greywater can be collected and reused for irrigation of nearby landscapes or green

areas, typically using subsurface or drip irrigation systems.

Results

Subject to the input data taken and the simulation processes applied GW flow obtained in the analysed examples was approximately 51.2 m³/day, occurring in a 60-floor high-rise building (HRB) with a storage tank located on the 20th floor. In this configuration, the elevation difference between the GW collection points and the turbine location reached about 132 m, providing favourable conditions for energy recovery.

The minimum GW flow observed under the study conditions was 12.8 m³/day. This occurred in cases where the elevation difference between GW collection points and the turbine was significantly smaller, approximately 33 m. Such a situation was observed in a 30-floor building with the collection tank on the 20th floor, as well as in a 50-floor building with the tank located on the 40th floor.

A 30 m³ collection tank was assumed in the simulations, representing a typical storage capacity capable of accommodating variations in GW production. The analysis assumes that GW generation follows a two-peaks (two-humps) daily pattern, corresponding to typical domestic water-use cycles. Water stored in the tank is released for energy production depending on the incoming flow and operational constraints of the selected turbine. The rate of water release from the storage tank depends on the available hydraulic head, flow rate, and turbine characteristics. These factors highlight the complexity of designing GW-based energy recovery systems in high-rise buildings. However, they also demonstrate the potential benefits of capturing otherwise wasted gravitational energy from greywater flows.

Acknowledgements

None

Conflict of Interest

The authors declare that there is no conflict of interest.