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The Potential of Greywater Utilization Through Circular Economy Approach in Urban Areas: A review

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Abstract

The development of urban areas in Indonesia continues to accelerate in line with increasing urbanization and rapid population growth. Greywater which is domestic wastewater from activities such as bathing and washing, accounts for 60–70% of total household wastewater and holds significant potential for reuse. This paper examines the optimization of greywater utilization through a circular economy approach that emphasizes recycle, reuse, and resource efficiency. The use of greywater not only helps reduce clean water consumption and the burden on wastewater treatment systems but also supports urban irrigation, sanitation, building cooling, and fire suppression. The implementation model includes the design of greywater collection systems, treatment technologies, and distribution networks. Environmental impacts include water conservation, pollution reduction, and energy savings, while economic benefits consist of lower operational costs, increased property value, and job creation. For city-scale implementation, regulations, financial incentives, spatial planning integration, public education, and cross-sector collaboration are essential. The optimization of greywater is considered a strategic step in supporting sustainable infrastructure development and in realizing resilient and competitive cities in the future.

Keywords: Circular economy, greywater, urban areas, water conservation, water treatment.

Abstrak

Pembangunan wilayah perkotaan di Indonesia terus mengalami percepatan seiring dengan meningkatnya urbanisasi dan pertumbuhan populasi yang pesat. Air limbah domestik kategori greywater, berkontribusi sekitar 60–80% timbulan air limbah yang berpotensi besar untuk dimanfaatkan kembali. Pada studi ini mengkaji optimalisasi pemanfaatan greywater melalui pendekatan ekonomi sirkuler yang menekankan daur ulang, penggunaan ulang, dan efisiensi sumber daya. Pemanfaatan greywater tidak hanya mampu mengurangi konsumsi air dan beban sistem pengolahan limbah, tetapi juga mendukung irigasi perkotaan, sanitasi, pendinginan bangunan, serta pemadaman kebakaran. Model implementasi mencakup desain sistem pengumpulan, teknologi pengolahan, dan distribusi greywater. Dampak lingkungan berupa konservasi air, pengurangan polusi, dan penghematan energi, sedangkan manfaat ekonomi meliputi pengurangan biaya operasional, peningkatan nilai properti, dan penciptaan lapangan kerja. Untuk implementasi skala kota, diperlukan regulasi, insentif, integrasi tata ruang, edukasi publik, serta kolaborasi lintas sektor. Optimalisasi greywater dinilai strategis dalam mendukung pembangunan infrastruktur berkelanjutan dan mewujudkan kota yang tangguh serta berdaya saing di masa depan.

Kata Kunci: *Air limbah rumah tangga, ekonomi sirkular, kawasan perkotaan, konservasi air, pengolahan air.*

INTRODUCTION

The development of urban areas in Indonesia continues to accelerate in line with increasing urbanization and rapid population growth. This situation presents major challenges in resource management, particularly water, which is a vital element in sustaining urban life. The rising demand for clean water, compounded by climate change and the limited availability of water resources, necessitates innovation in urban water management. One potential approach that has begun to receive attention is the utilization of greywater, or household wastewater that does not contain human excreta (Oh et al., 2018).

Greywater, which originates from the use of water in bathtubs, showers, sinks, and washing machines, accounts for nearly 60–80% of total household wastewater (Jakhar & Styszko, 2025). When properly managed, greywater can serve as an alternative water source for various purposes, such as irrigation, sanitation, and even reuse within clean water systems after undergoing filtration processes. In this context, optimizing greywater utilization not only reduces pressure on clean water resources but also supports the concept of a circular economy, in which resources are used efficiently and waste is minimized (Fountoulakis et al., 2016).

The circular economy emphasizes principles of sustainability by reducing waste, recycling materials, and optimizing resource utilization. When applied to greywater management, this concept can create a more sustainable and resilient water management system, particularly in densely populated urban areas. The implementation of a circular economy in urban infrastructure can further support sustainable development goals, such as reducing greenhouse gas emissions, improving energy efficiency, and preserving aquatic ecosystems (Suarez-Eiroa et al., 2019).

METHOD

This study aims to examine the concepts of sustainability and environmental friendliness in greywater treatment infrastructure, as well as the circular economy approach for wastewater management in Indonesia's city for urban areas. In addition, this study considers the characteristics of cities that directly influence greywater generation and management. Urban areas are typically marked by high population density, rapid urbanization, extensive commercial and industrial activities, and intensive water consumption patterns.

These conditions result in a significant volume of greywater accounting for up to 60–80% of household wastewater originating from daily activities such as bathing, washing, and cleaning. The concentration of high-rise residential buildings, commercial facilities, and centralized infrastructure systems further creates both challenges and opportunities for implementing large-scale greywater collection, treatment, and reuse.

This study adopts a literature-based research method using a structured review of peer-reviewed scientific journal articles as primary sources. Relevant publications were identified through academic databases such as Scopus, Web of Science, and Google Scholar using keywords including "greywater utilization," "urban water reuse," "circular economy," and "sustainability." Articles were selected based on their relevance to urban areas contexts, publication quality, and focus on environmental, economic, or policy aspects of greywater reuse.

The selected literature was analyzed using a descriptive and comparative approach. Each study was systematically reviewed to identify key themes related to greywater utilization, including implementation models, technological approaches, environmental impacts, economic feasibility, and regulatory frameworks. The circular economy perspective was incorporated by examining how greywater reuse contributes to resource efficiency, waste reduction, and closed-loop water management systems.

Furthermore, sustainability aspects were assessed by categorizing findings into environmental, economic, and social dimensions. Based on this synthesis, the study evaluates the potential of greywater utilization in urban areas and formulates policy recommendations and implementation strategies that support sustainable urban water management.

RESULTS AND DISCUSSION

The findings from the literature review indicate that greywater utilization has a strong correlation with the optimization of infrastructure development oriented toward a circular economy, particularly in urban areas of Indonesia.

Potential of Greywater Utilization

The availability of greywater in urban areas can be estimated by calculating the volume of water used for domestic purposes, excluding water used for toilets and other activities that generate blackwater, as shown in Figure 1 (Filali et al., 2022). For instance, in a household with an average water consumption of 200 Liters per person per day, approximately 120–140 Liters can be categorized as greywater (Khajvand et al., 2022). With the

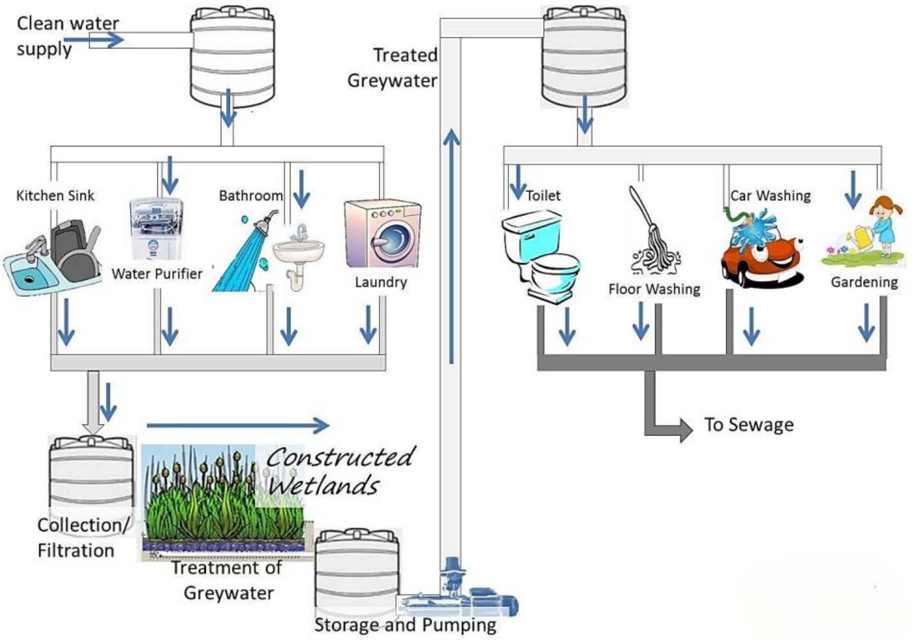

Figure 1 Illustration of Greywater Recycling. (Source: Naik, 2016).

Figure 2 Illustration of Urban Irrigation for Vegetation in Residential Areas. (Source: The Toro Company, 2022)

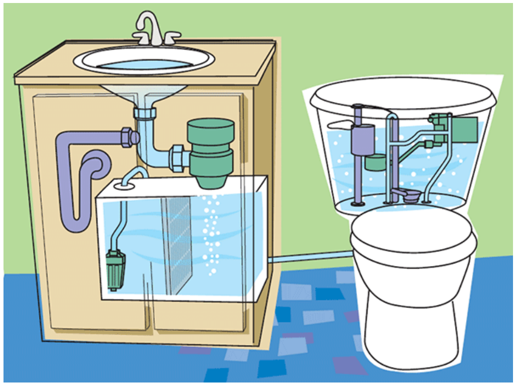

Figure 3 Illustration of Greywater Recycling for Toilet Flushing. (Source: INTERNachi, 2024)

population of Indonesia's cities reaching into the millions, the amount of available greywater is highly significant and offers substantial potential for reuse.

The potential of utilization of greywater in urban areas can provide considerable benefits across various aspects of basic urban infrastructure. The following are some of the potential applications of greywater: urban irrigation, sanitation and toilet systems, building cooling and fire suppression.

Greywater can be used for irrigating gardens, green spaces, and other forms of urban vegetation. This practice reduces the demand for clean water extracted from primary sources such as river intakes, thereby helping to conserve freshwater resources and reduce pressure on municipal distribution systems. Furthermore, since greywater contains nutrients such as phosphorus and nitrogen, which can benefit plant growth, it contributes to healthier vegetation without the need for additional fertilizers (Figure 2).

The reuse of greywater for sanitation systems, particularly toilet flushing, is one of the most common household-level applications. Utilizing greywater for this purpose can reduce clean water consumption in simple households by up to 30% (Radingoana et al., 2020).

To address water scarcity, a simple filtration technology is applied to remove physical and chemical impurities from greywater effluent, enabling its safe reuse for toilet flushing in accordance with minimum quality standards. As illustrated in Figure 3, this technology is cost-effective, easy to implement, and adaptable to local environmental conditions and community capacities. In addition to its technical benefits, the adoption of this system contributes to increased public awareness of sustainable wastewater management practices by promoting greywater utilization for sanitation purposes at both household and community levels. This approach demonstrates the potential of decentralized greywater treatment systems to support water conservation efforts and enhance the resilience of urban water management systems.

In several commercial and industrial buildings, greywater can be utilized as cooling water for HVAC (Heating, Ventilation, and Air Conditioning) systems or for fire suppression purposes, as shown in Figure 4. This practice not only reduces the demand for potable water but also lowers the operational costs of buildings. Greywater reuse systems can reduce freshwater consumption by approximately 30–70% in residential and commercial buildings, depending on the scale of application and end-use purposes such as toilet flushing (Olanrewaju & Ilemobade, 2015). Such an approach is particularly relevant in cities characterized by a high concentration of high-rise buildings and industrial facilities.

The utilization of greywater provides not only environmental benefits but also economic advantages. By reducing clean water consumption, cities can lower water distribution costs, decrease the burden on wastewater treatment systems, and strengthen resilience against future water shortages (Handoko, 2016). However, effective implementation requires careful planning, appropriate technologies, and supportive regulations to ensure that greywater is used safely and efficiently.

Circular Economy System Approach

The circular economy is a paradigm aimed at optimizing resource use through the principles of recycling, reusing, and repurposing materials previously regarded as waste (Kaimal & Sajoy, 2020). In the context of greywater management in cities, this approach is highly relevant because it can transform wastewater into a valuable resource. The application of circular economy principles to greywater management encompasses several key steps, including: strategies such as reduction and reuse, recycling, and greywater recovery.

Reduction and reuse are two core concepts in the circular economy approach applied to greywater management in cities (Ramirez-Agudelo et al., 2021). The primary objective of this strategy is to significantly reduce clean water consumption while reusing greywater for various non-potable purposes, thereby minimizing waste and optimizing the use of available water resources. Reducing clean water consumption by reusing greywater for non-potable needs such as irrigation and sanitation systems not only lessens dependency on limited water resources but also decreases the burden on clean water distribution systems.

The process of recycling and recovering greywater involves a series of treatment stages designed to remove contaminants and restore water quality so that it can be safely reused in various non-potable applications (Hibatullah, 2019). The main principle of this approach is to transform waste into a valuable resource, reduce the strain on clean water sources, and minimize wastewater discharged into the environment.

Several key principles in greywater recycling and recovery include: contaminant reduction through treatment technologies, nutrient and resource recovery, integration with municipal wastewater and water systems.

Greywater treatment technologies are designed to remove solid particles, chemicals, and microorganisms that could pose health risks or

Figure 4 Illustration of HVAC System in Office Buildings. (Source: Envigaurd, 2025)

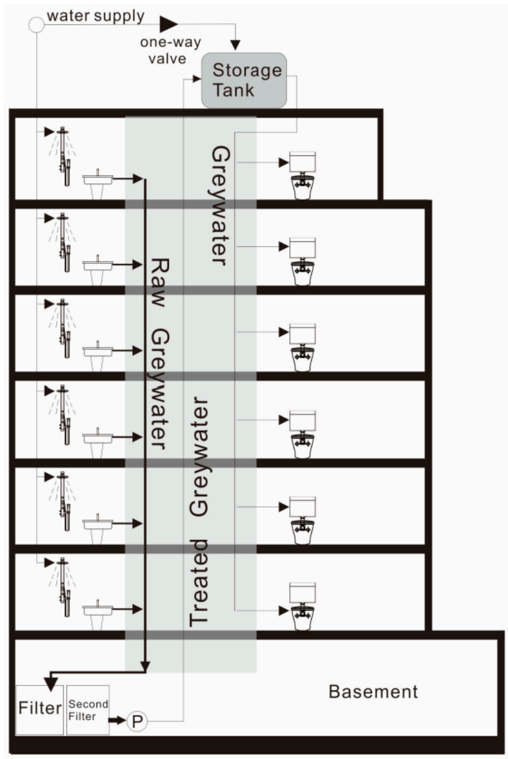

Figure 5 Scheme of greywater collection and distribution in Multi-Story Buildings. (Source: Juan et al., 2016)

cause environmental damage. Greywater contains nutrients such as phosphorus and nitrogen that, after treatment, can be reused for irrigation or urban agriculture. This nutrient recovery not only reduces the need for chemical fertilizers but also helps mitigate groundwater and surface water pollution. Furthermore, the treated greywater can be utilized for other purposes such as cooling or cleaning, thereby reducing the demand for clean water. Greywater recycling and recovery technologies should be integrated with existing wastewater and clean water management systems. This integration allows for greater efficiency in overall water resource management and ensures that treated water can be safely distributed and reused.

The implementation of circular economy systems in greywater management also involves collaboration among various stakeholders including government, industry, and communities to establish mutually beneficial value chains (Mbavarira et al., 2021).

Greywater Treatment and Distribution Systems

The application of greywater reuse on a urban scale requires efficient and effective treatment and distribution design. A well-designed system will produce outputs of higher quality for end use. The main components of a circular economy-based greywater implementation model include: greywater collection systems, greywater treatment technologies, distribution and reuse systems, as well as monitoring and maintenance.

Greywater collection begins at its source, such as households, commercial buildings, and public facilities. As shown in Figure 5, separate pipe installations channel greywater from bathtubs, sinks, and washing machines to storage tanks as the first step in the system. For households and multi-story buildings, the difference lies mainly in the quantity of inlet pipes and storage reservoirs prior to treatment. The design of the pipes and tanks must consider the volume of greywater generated and the temporary storage needs before processing. In addition, the system design should incorporate basic pretreatment measures, such as coarse screening or sedimentation, to prevent the accumulation of solids and organic matter that may affect downstream treatment performance. Proper hydraulic design is also essential to avoid stagnation and odor formation during storage, particularly in warm urban environments. Furthermore, routine maintenance and monitoring of storage tanks and pipe networks are required to ensure operational reliability and maintain the quality of greywater prior to treatment.

Greywater treatment technologies vary depending on the intended end use. For irrigation purposes, simple filtration may suffice, while applications in sanitation or cooling systems require more advanced technologies such as biofilters , membrane filtration. The selection of appropriate treatment technology should therefore be based on water quality requirements, system complexity, and operational and maintenance considerations to ensure safe and sustainable reuse. Technology choices must take into account energy efficiency, operational costs, and the quality of water produced. For example, if greywater is used only at the household scale and sourced primarily from sinks, simple granular filtration systems may be adequate (Figure 6). However, in building with diverse sources, more advanced technologies for treatment and disinfection process such as Ultra Violet (UV) systems or ozone method may be necessary (Wenjun et al., 2024) .

Once treated, greywater is redistributed through separate pipelines for various applications such as urban irrigation, sanitation, and building cooling. The distribution network design must consider the location of end users, required water meter, water pressure, water quality online monitoring and system maintenance (Adu-Manu et al., 2017). In addition, integration with municipal water management systems allows greywater to be flexibly used based on demand and availability. The implementation of greywater systems requires strict monitoring mechanisms to ensure that water quality remains safe and meets established standards. Automated monitoring systems can be used to detect contamination and assess system performance in real time. Routine maintenance is also essential to prevent deterioration in water quality and system failures (Ahmed et al., 2020).

Environmental and Economic Impacts of Greywater Utilization

The use of greywater as part of sustainable infrastructure development based on a circular economy system in cities has significant environmental and economic impacts. Proper implementation not only helps reduce pressure on clean water resources but also provides economic benefits that can foster long-term sustainability (Makanda et al., 2022). The environmental impact of greywater utlization identified from some literatures as follows: reduction in clean water consumption, the reduced burden on wastewater treatment systems, as well as the reduction of pollution and environmental contamination.

Greywater utilization directly decreases the demand for clean water, especially for non-potable purposes such as irrigation, toilet flushing, and cleaning. By lowering clean water demand, cities can maintain the balance of aquatic ecosystems and reduce pressure on scarce water resources. This is especially crucial in urban areas that often face

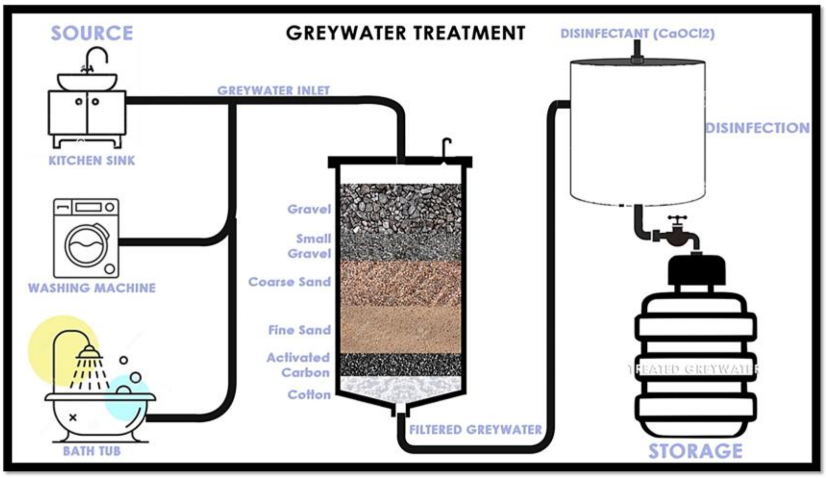

Figure 6 Scheme of filtration system for greywater treatment. (Source: Makhitha et al., 2021)

water availability challenges due to population growth and climate change (Stavenhagen et al., 2018).

Reusing greywater reduces the volume of wastewater that must be treated by municipal systems. This improves treatment efficiency and lowers the risk of water pollution caused by overloaded facilities. The reduced burden also has the potential to extend the lifespan of existing wastewater infrastructure and minimize the need for costly new investments (Tarpani & Azapagic, 2018). Properly Reduction of Pollution and Environmental Contamination treated greywater lowers the amount of wastewater discharged into sewer systems, thereby reducing the potential for groundwater and surface water contamination. By decreasing pollutants such as household chemicals, excessive nutrients, and pathogenic microorganisms in discharged wastewater, surrounding water quality can be preserved and aquatic ecosystems protected (Akhtar et al. 2021).

Energy Conservation and Carbon Footprint Reduction

The treatment and distribution of clean water require significant energy inputs. By reducing dependence on clean water through greywater utilization, energy consumption associated with water treatment also decreases (Zavala et al., 2016). Additionally, lower clean water usage and more efficient wastewater management contribute to reduced greenhouse gas emissions, helping cities achieve carbon footprint reduction targets. Alongside environmental impacts, greywater utilization also yields several economic benefits, including: operational cost savings, increased property and infrastructure value, job creation and new industries, reduced financial burden on water infrastructure, as well as enhanced economic resilience of cities.

One of the primary economic benefits of greywater utilization is substantial cost savings for both municipal governments and communities. By reusing greywater for non-potable applications, expenses associated with clean water procurement and treatment can be reduced. These savings may be redirected to fund other sustainability initiatives or to ease financial burdens on households through lower water tariffs (Brown et al., 2020). Properties equipped with greywater utilization systems often hold higher value than those without, as such systems demonstrate a commitment to sustainability and resource efficiency attributes increasingly valued by consumers. Moreover, city infrastructure that supports greywater reuse can attract investment and promote more sustainable economic development (Silva, 2023).

The development and implementation of greywater utilization technologies can stimulate new industries, such as greywater treatment equipment manufacturing, installation services, and maintenance providers. This fosters job creation in the green technology sector and enhances the skills of the local workforce in sustainability-related fields (Khan et al., 2025). By decreasing the volume of water that must be treated and distributed through municipal clean water systems, the financial strain on water infrastructure is reduced. This enables city governments to allocate resources to other pressing areas, such as infrastructure maintenance or the development of additional public services. Furthermore, this reduction can delay or even eliminate the need for costly water infrastructure expansion, thereby providing significant long-term savings (Pot, 2023). By reducing dependency on limited clean water resources, cities can strengthen their resilience against economic fluctuations caused by water crises, such as droughts or rising water costs (O'Connell, 2017). Such resilience is essential for maintaining urban economic stability and ensuring that the population's basic needs continue to be met under diverse environmental and economic conditions.

Policy Recommendations and Implementation Strategies

The utilization of greywater in sustainable infrastructure development in cities is a strategic step toward optimizing limited water resources and reducing environmental impacts (Tansar et al., 2024). When integrated into urban water management planning, greywater reuse systems can also enhance water security and support long-term sustainability goals in densely populated areas. To achieve this goal, supportive policies and comprehensive implementation strategies are required. The following policy recommendations and implementation strategies can be applied.

Policy Recommendations

Municipal governments must establish clear and comprehensive regulations and standards for greywater quality. These regulations should include water quality requirements, treatment procedures, and guidelines for the reuse of greywater in various non-potable applications (Vuppaladadiyam et al., 2018). The standards must be based on comprehensive scientific research and adapted to local conditions and the specific needs of urban areas, including financial incentives for greywater technology implementation, integration of greywater into spatial planning and infrastructure development, public education and awareness campaigns, as well as the strengthening of cross-sectoral collaboration.

To encourage the adoption of greywater treatment technologies, municipal governments can provide financial incentives such as subsidies, tax reductions, or affordable financing schemes for communities, property developers, and industries that invest in greywater treatment infrastructure (Thaher et al., 2020). These incentives will reduce the initial investment burden and accelerate the adoption of greywater technologies citywide. Urban spatial planning policies must integrate greywater utilization as part of city water management strategies. This includes incorporating greywater treatment and distribution systems into new infrastructure designs, as well as upgrading existing infrastructure to support greywater use. Such integration should be reinforced by policies requiring greywater systems in new large-scale development projects (Finewood, 2016).

Effective policies must be supported by extensive public education campaigns to increase community awareness of the importance of greywater utilization. These programs should provide information on how to separate and treat greywater, explain the economic and environmental benefits of its use, and offer practical guidance for implementation at homes and workplaces. Education efforts may also involve collaboration with schools, universities, and research institutions (Sulaiman et al., 2025). Governments must establish cross-sector partnerships involving stakeholders such as the private sector, research institutions, and civil society. Such collaboration is essential for technology development, innovation, and knowledge exchange in greywater management. In addition, public-private partnerships can be utilized to finance and manage complex greywater infrastructure projects (Shahdadi et al., 2023).

Implementation Strategies

Implementation strategies must begin with the development of adequate greywater treatment infrastructure across the city. This includes the construction of small- to large-scale treatment facilities integrated with existing clean water and wastewater systems. The infrastructure must be designed for energy efficiency, minimal environmental impact, and adapted to the specific conditions of each urban area (Gong & Hu, 2017). Additional measures include pilot projects in urban areas, monitoring and evaluation, capacity building and training, the development of sustainable business models, as well as the adoption of innovative technologies. As an initial step, municipal governments can launch pilot projects in selected areas, such as residential districts, commercial buildings, or industrial zones. These projects serve as implementation models that can be evaluated and refined before broader citywide application. The outcomes of pilot projects can be used to improve broader policies and technical guidelines (Bundgaard & Borras, 2021).

Rigorous oversight and continuous evaluation are essential components of implementation strategies. Municipal governments should establish monitoring systems to oversee the quality of treated greywater, utilization rates, and its impacts on the environment and public health. Data collected from monitoring can be used to assess the effectiveness of existing policies and make necessary adjustments (Dube et al., 2016). Successful implementation requires technical capacity building and training for personnel involved in greywater management. Training should cover the operation of treatment technologies, infrastructure maintenance, and water quality monitoring. Additionally, training for regulators and policymakers is also necessary to ensure that they possess a deep understanding of the technical and regulatory aspects of greywater management (Kyriakopoulos, 2023).

Establishing sustainable business models is crucial to ensure the long-term viability of greywater utilization. These models may include water tariff schemes that encourage reuse, partnerships with the private sector for facility operation, and waste management initiatives that integrate recycling and recovery. By creating appropriate economic incentives, municipal governments can ensure that greywater management systems remain both sustainable and profitable (Godyn, 2022). Urban areas must continue to adopt and innovate with the latest technologies in greywater treatment to improve efficiency and reduce environmental impacts (Sunny, 2024). Advanced biological treatment, the use of renewable energy in treatment systems, and real-time water quality monitoring should be explored and implemented in accordance with urban needs. These technologies must also be regularly evaluated to ensure effectiveness and relevance to local conditions.

CONCLUSION

This study set out to examine the sustainability aspects and circular economy approach in optimizing greywater utilization within cities in Indonesia. The review findings demonstrate that greywater, which constitutes 60–80% of domestic wastewater, holds significant potential as an alternative resource when supported by proper collection, treatment, and distribution systems. By adopting a circular economy perspective, greywater management can enhance resource efficiency, reduce clean water consumption, lower the burden on wastewater treatment facilities, and mitigate environmental pollution.

The analysis also confirms that sustainable greywater infrastructure contributes not only to environmental conservation but also to economic benefits such as operational cost savings, increased property value, and job creation. These outcomes align with the aims of the study by showing how circular economy principles can be practically applied to wastewater management to foster resilient, inclusive, and sustainable urban development. To fully realize this potential, cross-sectoral collaboration, enabling regulations, financial incentives, and continuous innovation are required. Ultimately, optimizing greywater utilization represents a strategic pathway toward sustainable infrastructure that answers both the environmental and economic challenges of urban areas growth in Indonesia.

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REFERENCES

Adu-Manu, K.S., Tapparello, C., Heinzelman, W. (2017). Water Quality Monitoring Using Wireless Sensor Networks: Current Trends and Future Research Directions. ACM Transactions on Sensor Networks, Vol. 13, No. 1, Article 4. http://dx.doi.org/10.1145/3005719

Ahmed, U., Mumtaz, R., Anwar, H., Mumtaz, S., Qamar, A.M. (2020). Water quality monitoring: from conventional to emerging technologies. Water Supply, Vol. 20, No. 1. https://doi.org/10.2166/ws.2019.144

Akhtar, N., Ishak, M.I.S., Bhawani, S.A., Umar, K. (2021). Various Natural and Anthropogenic Factors Responsible for Water Quality Degradation: A Review. Water 2021, Vol. 13, No. 19. https://doi.org/10.3390/w13192660

Brown, M.A., Soni, A., Lapsa, M.V., Southworth, K., Cox, M. (2020). High energy burden and low-income energy affordability: conclusions from a literature review. Prog. Energy 2 (2020) 042003. https://doi.org/10.1088/25161083/abb954

Bundgaard, L., Borras, S. (2021). City-wide scale-up of smart city pilot projects: Governance conditions. Technological Forecasting and Social Change 2021 Vol. 172, 121014; https://doi.org/10.1016/j.techfore.2021.121014

Dube, R.A., Maphosa, B., Fayemiwo., O.M. (2016). Adaptive Climate Change Technologies and Approaches for Local Governments: Water Sector Response. Water Research Commission Republic of South Africa, 2016. ISBN: 978-1-4312-0792-3.

Envigaurd. (2025). What is HVAC System, and how does it work?. https://envigaurd.com/topics/what-is-hvac-system/

Filali, H., Barsan, N., Souguir, D., Nedeff, V., Tomozei, C., & Hachicha, M. (2022). Greywater as an Alternative Solution for a Sustainable Management of Water Resources-A Review. Sustainability 2022, 14 (2), 665. https://doi.org/10.3390/su14020665.

Finewood, M.H. (2016). Green Infrastructure, Grey Epistemologies, and the Urban Political Ecology of Pittsburgh's Water Governance. Antipode Vol. 48 No. 4 , 1000-1021. https://doi.org/10.1111/anti.12238

Fountoulakis, M.S., Markakis, N., Petousi, I., Manios, T. (2016). Single house onsite grey water treatment using a submerged membrane bioreactor for toilet flushing, Science of The

Total Environment, Volumes 551–552, 2016, Pages 706-711, ISSN 0048-9697. https://doi.org/10.1016/j.scitotenv.2016.02.057.

Godyn, I. (2022). Economic Incentives in Stormwater Management: A Study of Practice Gaps in Poland. Water 2022, Vol. 14(23) 3817. https://doi.org/10.3390/w14233817

Gong, C., Hu, C. (2017). The research of gray space design of architecture based on green stormwater infrastructure application. Energy Procedia Journal Vol. 117, 2017, 219; https://doi.org/10.1016/j.egypro.2017.05.020

Handoko, J.P.S., (2016). Optimalisasi Pemanfaatan Greywater Pada Bangunan Rumah Susun Sebagai Upaya Mewujudkan Sustainable Architecture. Jurnal Arsitektur, Bangunan & Lingkungan Vol. 5, No.2, Februari 2016 : 59-104. ISSN: 2088-8201.

Hibatullah, H.F., (2019). Fitoremediasi Limbah Domestik (Grey Water) Menggunakan Tanaman Kiambang (Salvinia molesta) Dengan Sistem Batch. Tugas Akhir : Universitas Islam Negeri Sunan Ampel Surabaya (Surabaya : Indonesia).

International Association of Certified Home Inspectors INTERNachi. (2024). Greywater Inspection. https://www.nachi.org/greywater-inspection.htm

Jakhar, R., Styszko, K. (2025). Recent Trends in Emerging Greywater Management in India: An Overview. Desalination and Water Treatment, Volume 322, April 2025, 101226. https://doi.org/10.1016/j.dwt.2025.101226

Juan, Y., Chen, Y., Lin, J. (2016). Greywater Reuse System Design and Economic Analysis for Residential Buildings in Taiwan. Water 2016, 8, 546. https://doi.org/10.3390/w8110546

Kaimal, M.M., Sajoy, P.B. (2020). Circular Economy – A Paradigm Shift for Sustainable Development. Perspective On Business Management & Economics Volume I. June 2020. Pages 132-142. ISBN: 978-81-946245-3-0.

Khajvand, M., Mostafazadeh, A.K., Drogui, P., Tyagi, R.D. (2022). Management of Greywater: Environmental Impact, Treatment, Resource Recovery, Water Recycling, and Decentralization. Water Science & Technology, Vol. 86 (5): 909–937. https://doi.org/10.2166/wst.2022.226

Khan, S.A., Patoli, A.Q., Ahmed, A., Ahmed, I. (2025). nnovations in Green Technologies: Analyzing Their Contribution to Job Creation and Sustainable Economic. Review of Applied Management and Social Sciences (RAMSS) Vol. 8, (1) 2025 ,263-277; https://doi.org/ 10.47067/ramss.v8i1.456

Kyriakopoulos, G.L. (2023). Chapter 10 - Circular economy and sustainable strategies: Theoretical framework, policies and regulation challenges, barriers, and enablers for water management. Water Management and Circular Economy 2023, 197-230. https://doi.org/10.1016/B978-0-323-95280-4.00014-X

Makanda, K., Nzama, S., Kanyerere, T. (2022). Assessing the Role of Water Resources Protection Practice for Sustainable Water Resources Management: A Review. Water 2022, 14(19), 3153; https://doi.org/10.3390/w14193153

Makhitha, L., Gupta, A., Jay, B., James, J., Gajendran, C. (2021). Treatment and Effective Utilization of Greywater: A Preliminary Case Study. Applied System Innovation. 4. 10.3390/asi40100.

Mbavarira, T.M., Grimm, C. A. (2021). Systemic View on Circular Economy in the Water Industry: Learnings from a Belgian and Dutch Case. Sustainability 2021, 13, 3313. https://doi.org/10.3390/su13063313

Naik, R. (2016). Recycle Greywater to Reduce Urban Water Needs. https://rajeshnaik.com/recycle_grey_water_to_reduce_urban_water_needs/

O'Connell, E. (2017). Towards Adaptation of Water Resource Systems to Climatic and Socio-Economic Change. Water Resource Management. Volume 31, pages 2965–2984, (2017). https://doi.org/10.1007/s11269-017-1734-2

Oh, K.S., Leong, J.Y.C., Poh, P.E., Chong, M.N., Lau, V.E. (2018). A review of greywater recycling related issues: Challenges and future prospects in Malaysia, Journal of Cleaner Production, Volume 171, 17-29, ISSN 0959-6526. https://doi.org/10.1016/j.jclepro.2017.09.267

Olanrewaju, O.O., Ilemobade, A.A. (2015). Greywater Reuse Review and Framework for Assessing Greywater Treatment Technologies for Toilet Flushing. Journal of Advances in Research 5(4): 1-25, 2015, Article no.AIR.19117. ISSN: 2348-0394.

Pot, W. (2023). Deciding for resilience: Utilizing water infrastructure investments to prepare for the future. WIREs Water. 2023;10:e1661. https://doi.org/10.1002/wat2.1661

Radingoana, M.P., Dube, T., Mazvimavi, D. (2020). Progress in greywater reuse for home gardening: Opportunities, perceptions and challenges, Physics and Chemistry of the Earth, Parts A/B/C, Volume 116, 2020, 102853, ISSN 1474- 7065. https://doi.org/10.1016/j.pce.2020.102853

Ramirez-Agudelo, N.A., de Pablo, J., Roca, E. (2021). Exploring alternative practices in urban water management through the lens of circular economy– A case study in the Barcelona metropolitan area, Journal of Cleaner Production, Volume 329, 2021, 129565, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2021.129565.

Shahdadi, L.M., Aminnejad, B., Sarvari, H., Chan, D.W.M. (2023). Determining the Critical Risk Factors of Implementing Public–Private Partnership in Water and Wastewater Infrastructure Facilities: Perspectives of Private and Public Partners in Iran. Building 2023 Vol. 13, No. 11, 2735; https://doi.org/10.3390/buildings13112735.

Silva, J.A. (2023). Water Supply and Wastewater Treatment and Reuse in Future Cities: A Systematic Literature Review . Water 2023 15(17), 3064; https://doi.org/10.3390/w15173064 .

Stavenhagen, M., Buurman, J., Tortajada, C. (2018). Saving water in cities: Assessing policies for residential water demand management in four cities in Europe. Cities 2018, 79, 187. https://doi.org/10.1016/j.cities.2018.03.008

Suárez-Eiroa, B., Fernández, E., Méndez-Martínez, G., Soto-Oñate, D. (2019). Operational principles of circular economy for sustainable development: Linking theory and practice, Journal of Cleaner Production, Volume 214, 2019, Pages 952-961, ISSN 0959-6526. https://doi.org/10.1016/j.jclepro.2018.12.271.

Sulaiman, M.O., Mackey, H.R., Al-Ghouti, M.A., Saththasivam, J., Abu-Dieyeh, M.H. (2025). Perspectives of Utilizing Greywater in Agricultural Irrigation with a Special Reference to Vegetated Wall Agrosystems. Water 2025, Vol. 17, No. 1., 103. https://doi.org/10.3390/w17010103

Sunny, M.A.U. (2024). Sustainable Water Management in Urban Environments. European Journal of Advances in Engineering and Technology, 2024, 11(4):88-95. ISSN: 2394 -658X.

Tansar, H., Li, F., Zheng, F., Duan, H. (2024). A critical review on optimization and implementation of green-grey infrastructures for sustainable urban stormwater management. AQUA — Water Infrastructure, Ecosystems and Society Vol 73 No 6, 1135. https://doi.org/ 10.2166/aqua.2024.310

Tarpani, R.R.Z., Azapagic, A. (2018). Life cycle costs of advanced treatment techniques for wastewater reuse and resource recovery from sewage sludge. Journal of Cleaner Production 2018, 204, 832. https://doi.org/10.1016/j.jclepro.2018.08.300

Thaher, R.A., Mahmoud, N., Al-Khatib, I.A., Hung, Y.T. (2020). Reasons of Acceptance and Barriers of House Onsite Greywater Treatment and Reuse in Palestinian Rural Areas. Water 2020 Vol 12 No 6, 1679. https://doi.org/10.3390/w12061679

The Toro Company. (2022). Smart Irrigation Water Management. https://www.greenindustrypros.com/irrigation-water-management/smart-irrigation-water-management/article/22301600/the-toro-company-advantages-of-smart-controllers

Vuppaladadiyam, A.K., Merayo, N., Prinsen, P., Luque, R., Blanco, A., Zhao, M. (2018). A review on greywater reuse: quality, risks, barriers and global scenarios. Reviews in Environmental Science and Bio/Technology Vol 18 No 77-99. https://doi.org/10.1007/s11157-018-9487-9

Wenjun, S., Xiuwei, A., Dongmin, L., Yuanna, Z., Yanei, X., Siyuan, H., Xi, Z., Ted, M. (2024). Ultraviolet technology application in urban water supply and wastewater treatment in China: Issues, challenges and future directions. Water 2024, 23, 100225. https://doi.org/10.1016/j.wroa.2024.100225

Zavala, M.A.L., Vega, R.C., Miranda, R.A.L. (2016). Potential of Rainwater Harvesting and Greywater Reuse for Water Consumption Reduction and Wastewater Minimization. Water 2016, 8(6), 264; https://doi.org/10.3390/w8060264