REKA ELKOMIKA: Jurnal Pengabdian kepada Masyarakat
ISSN(p): 2723-3235 | ISSN(e): 2723-3243 | Vol. 5 | No. 1 | Pages 31 - 40
DOI : 10.26760/rekaelkomika.v5i1.31-40 January 2024

Application of Treatment Technology, Grey Water Waste Management and Rainwater Harvesting in the Environment of RW 11 Bandung City

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Received 26 October 2023 **|** Revised 16 December 2023 **|** Accepted 20 December 2023

ABSTRACT

This project addresses critical water resource challenges in urban areas, particularly in Bandung City, Indonesia, where increased demand due to a high population exacerbates groundwater depletion and clean water scarcity. The area of focus is RW 11, Kel. Sukaluyu, Cibeunying Kaler District, which suffers notably from droughts and a significant lack of clean water. The proposed solution involves the development of portable, home-scale technology for the treatment and reuse of greywater and rainwater. This innovative approach is designed to decrease reliance on groundwater and provide a reliable water source during dry seasons. Additionally, the project aims to educate the local community in RW 11 about the importance of maintaining the groundwater cycle. The ultimate goal is to alleviate water scarcity in the area, especially during drought periods, thereby contributing to sustainable water resource management in urban contexts.

***Keywords**: grey water; rain water harvesting; household waste*

1. INTRODUCTION

In large cities like Bandung, where the population exceeds 1 million, the demand for water significantly outstrips the Indonesian National Standard of 120 liters per person per day, reaching over 150 liters per person per day **(Hidayat et al., 2019).** This leads to daily water consumption exceeding 150,000 m³. Bandung's Regional Water Company (PDAM) serves 175,436 customers, distributing 35,879,133 m³ annually. The city's reliance on groundwater is causing a decline in levels, risking water crises and droughts, exacerbated by the inefficient use of water where it's often used only once. This underscores the need for water reuse and repurposing in daily activities. In developing countries, the composition of domestic wastewater is approximately 70% greywater and 30% blackwater **(Fauzan, 2017) (Shakes Jnr, 2020).** In addition to utilizing greywater, another underutilized potential resource is rainwater **(Aprilia, 2022)**. Bandung, with its high rainfall, can be an advantage for its residents if rainwater is effectively collected, managed, and utilized **(Lestari et al, 2021)**. In RT 2 of RW 11, Sukaluyu Subdistrict, facing water scarcity due to high household density and groundwater dependence, the "Implementation of Greywater Treatment, Management, and Rainwater Harvesting Technology" project addresses these issues **(Ramadhayanti et al,**

2021). It introduces a natural resource management program utilizing greywater and rainwater, develops affordable eco-friendly devices for these purposes, and establishes long-term partnerships for ongoing implementation and monitoring.

The expected outcomes of solution (1) include guidelines for managing greywater and rainwater harvesting in the form of pocketbooks and posters. It is hoped that the pocketbook will enable the community to disseminate the knowledge they have gained, while the posters are expected to serve as reminders and enticing invitations for other community members to collectively manage greywater and rainwater harvesting wisely. This approach is aimed at ensuring the sustainability of the program. The expected outcomes of solution (2) are the creation of portable, easy-to-build, install, and maintain household-scale devices to assist the community in managing greywater and rainwater. Solution (3) targets user satisfaction with the program's performance and devices.

Greywater can address water deficits in urban areas by serving as an alternative water source. The treated greywater can be used for various daily purposes, such as vehicle washing, toilet flushing, plant irrigation, and other outdoor needs. Greywater treatment also helps reduce liquid waste from households that enters the city's drainage system (Qomariyah, Koosdaryani, and Fitriani, 2016). Treated greywater can be used for watering plants if the greywater source comes from laundry, ablution, or kitchen activities **(Handayani, 2014).** Greywater also contains chemicals from soap or detergents, including sodium, potassium, and calcium, which tend to increase soil alkalinity when used for plant irrigation **(Handoko, 2016).** The addition of filtration media in greywater treatment significantly affects water clarity. Filtration systems using media such as zeolite, activated carbon, and coconut fibers can reduce COD and TSS parameters in household wastewater. Moreover, the use of filtration media can alter the pH value and reduce water turbidity **(Saputri, 2021).** Household greywater and rainwater harvesting, when used together, can reduce the consumption of clean water and groundwater, which is currently on the rise. Many people still believe that water used for daily needs must be pure and sacred, limiting the use of greywater in households. However, research results show that the utilization of greywater and rainwater has an efficiency level that can reduce clean water usage by 21.12% - 58.47% **(Hidayat et al., 2019) (Susanawati et al., 2018).** The concept of Rainwater Harvesting (RWH) involves collecting, storing, and utilizing rainwater. The storage tank's capacity in RWH significantly influences the system's performance. The most crucial component of the RWH system is the storage tank, as the cost and system performance are determined by this tank. Factors affecting tank performance include water requirements, rainfall intensity, and catchment area characteristics **(Juliana and Sriwijaya, 2019)**.

The Rainwater Harvesting System's Capacity (DDPAH) is influenced by roof area, rainfall intensity, and tank volume. Based on simulation results, the DDPAH value contributes to meeting domestic water needs for five years. The required storage tank should be larger with a larger roof area to eliminate runoff. For optimal and effective rainwater harvesting to meet water needs, a linear relationship between storage tank size and roof area is required **(Putra, 2023).** In RW 11, Sukaluyu Subdistrict, the lack of wastewater management initiatives has led to a positive reception of our team's solutions, aimed at enhancing groundwater sustainability awareness and establishing role models in greywater treatment and rainwater harvesting. This project serves as a practical learning platform for students, enabling them to develop and apply waste management concepts and technologies, and to promote these innovations among local residents.

2. IMPLEMENTATION METHOD

Located in RW 11, Sukaluyu Subdistrict, Cibeunying Kaler District, Bandung City, our community engagement project spans a duration of seven months, from June to December. The project team comprises three faculty members from the disciplines of Civil and Mechanical Engineering, along with ten students specializing in these fields. Collaborating closely with the RT RW management in the RW 11 area of Sukaluyu, Bandung, the project encompasses participation from one representative of each of the nine RTs in the locality. This initiative, rooted in the RW 11, Sukaluyu, Cibeunying Kaler District of Bandung City, is grounded in the principles of Community-Based Participatory Research (CBPR). This methodology has been selected for its effectiveness in engaging the community as an integral partner in all aspects of the research and development process, with a particular focus on greywater management and rainwater harvesting systems.

The Community-Based Participatory Research (CBPR) approach for greywater treatment and rainwater harvesting in RW 11 involved several integrated phases. Initially, a Literature Review established an understanding of local challenges and solutions. This progressed to a Preliminary Survey and Problem Identification through interviews with the RW 11 Chairman and residents, ensuring community-centric project development. Next, the Development of Management Concepts and Designs, achieved through collaborative community brainstorming, produced a practical guideline pocketbook. The Program Dissemination phase then educated residents about groundwater and raw water management, incorporating their feedback for program and design refinement. Subsequently, the Preparation and Device Fabrication phase saw residents actively involved in constructing greywater and rainwater harvesting devices. The Device Installation and Program Implementation phase enabled residents to use these devices and apply the program, enhancing their practical understanding. Finally, the Evaluation phase involved regular assessments and community feedback to measure satisfaction and usability of the program and devices.

By employing the CBPR approach, this project focuses not only on technical solutions but also on strengthening community engagement and capacity. This approach ensures that the solutions developed are inclusive, sustainable, and tailored to the specific needs of the RW 11 community. We believe that deep community involvement through CBPR will have a long-term impact on water resource management in the area **(Isyanto et al, 2015)**.

The operation of the greywater system, as depicted in Figure 1, proceeds through a series of purification stages. Initially, wastewater from washing activities is directed into the first tank, where primary sedimentation of solids occurs. Once the first tank is filled, the water flows into the second tank for further sedimentation of any carried-over solids. In the third tank, aquatic plants absorb toxic substances from the water, further cleansing it. The subsequent stage occurs in the fourth tank, where live fish serve as indicators of water cleanliness, signifying its suitability for reuse. Finally, after passing through the fourth tank, the water moves into the fifth tank, where it is now treated and ready for reuse (figure 1).

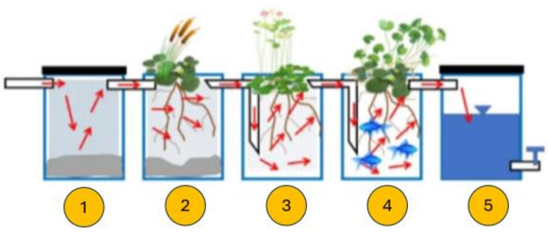

Figure 1. Gray Water Tool Working System

Table 1 presents detailed information on the equipment and materials required for constructing a greywater system for one unit.

Table 1. Materials and Equipment for Greywater Production

No	Equipment	Unit	Quantity
1	80-liter plastic drum	Unit	5
2	Water faucet 1"	pcs	1
3	1" external thread socket	Pcs	10
4	1" rubber gaske	Pcs	20
5	Internal thread socket	Pcs	10
6	Large rubber seal	Pcs	2
7	Asahi glue	Pcs	1
8	3/4" external thread socket	Pcs	5
9	3/4" internal thread socket	Pcs	10
10	1" pipe	Pcs	2
11	3/4" rubber gasket	Pcs	10
12	3/4" stopcock	Pcs	5
13	3/4" pipe	Pcs	3
14	Fine sandpaper	Sheet	2
15	Knee Joint	Pcs	3

The operation of the Rainwater Harvesting (RWH) system, as illustrated in Figure 2, functions as follows: Rainwater captured by the gutter is channeled into the first pipe, which is equipped with a filter to screen out coarse debris. The water then flows into the second pipe, where a sedimentation process occurs, settling fine particles initially carried along. Once the second pipe is filled, the water transitions to a container linked to the third pipe and subsequently enters tank four. When tank four is full, excess water is expelled through pipe five. Water that is collected and ready for daily use can be accessed via pipe or faucet six (figure 2).

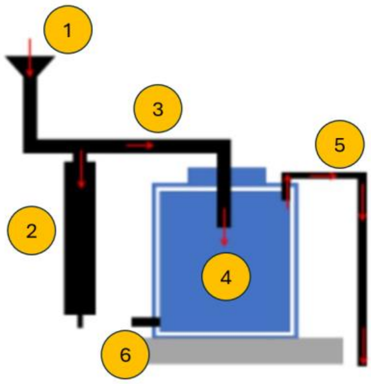

Figure 2. Rain Water Harvesting Tool Working System

Table 2 provides detailed information on the equipment and materials necessary for constructing a rainwater harvesting system for a single unit.

Table 2. Materials and Equipment for Rain Water Harvesting

No	Equipment	Unit	Quantity
1	3" pipe	Pcs	2
2	Reducer pipe (Shocklock) 3" > 6"	pcs	1
3	3" T-connector pipe	Pcs	3
4	6" pipe	Pcs	1
5	3" one-way valve	Pcs	1
6	6" cap	Pcs	1
7	3" filter	Pcs	1
8	Funnel	Pcs	1
9	3" Valve/Stopcock	Pcs	1
10	3" knee joint	Pcs	3
11	1" external thread socket	Pcs	2
12	1" internal thread socket	Pcs	3
13	1" stopcock	Pcs	2
14	Asahi glue	Can	1
15	Fine sandpaper	Sheet	1
16	Torn cap filter	Pcs	1
17	Large seal tape	Pcs	2
18	Hexagonal paving block	Pcs	30
19	3" water faucet	Pcs	3
20	3" external thread socket	Pcs	2
21	3" internal thread socket	Pcs	2
22	1" rubber gasket	Pcs	4
23	3" rubber gasket	Pcs	4
24	1" pipe	Pcs	1
25	800-liter tank	Unit	1

3. RESULT AND DISCUSSION

3.1 Outcome Results from Community Service Activities

The achieved outcomes and results up to this point include the installation of 1 unit of greywater treatment and 1 unit of Rainwater Harvesting (RWH) in the RW 11 community, Sukaluyu Subdistrict, Cibeunying Kaler District, Bandung City. Figure 3 illustrates the assembly process of the Grey Water system conducted by the community service team.

Figure 3. Gray Water Making Process

Furthermore, guidelines for managing greywater and rainwater harvesting have been provided in the form of pocketbooks distributed to all participants in the socialization program and the RT and RW management. The socialization activities and the handover of the equipment have been publicized in online print media. The purchase of 4 units of greywater treatment and RWH systems, to be subsequently installed at locations determined by the RT and RW management, has been initiated. Figure 4 illustrates the assembly process of the Rain Water Harvesting system conducted by the community service team.

Figure 4. RWH Making Process

Figure 5. Installation RWH and Grey Water Unit

Figure 5 illustrates the installation of the Rainwater Harvesting and Grey Water Unit systems, a process that encountered several challenges. Firstly, there was reluctance among residents to install greywater treatment equipment due to existing waste disposal practices at their homes, which often necessitated complex floor excavations for installation. Secondly, the dense and narrow layout of the residential area posed difficulties in finding adequate space for Rain Water Harvesting equipment. Lastly, the installation required additional materials and media, such as water filtering media, water hyacinth plants, concrete pouring, and iron brackets for equipment support, alongside skilled labor for the final stages of installation.

In addition to the development and implementation of greywater and Rain Water Harvesting (RWH) equipment, several other significant outputs have been achieved in this project. These outputs include:

1. Electronic Media Publication: The creation and distribution of electronic publications focused on information regarding the socialization activities and the handover process of the greywater and RWH equipment. These publications aim to provide broader knowledge and awareness of the project to the community and stakeholders. The results of this output can be seen in Figure 6.

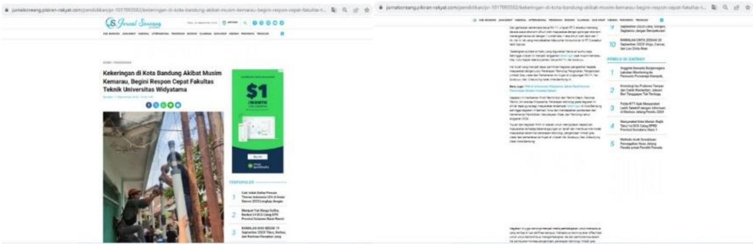

Figure 6. Capture of Media Publication

Source : https://jurnalsoreang.pikiran-rakyat.com/pendidikan/pr-1017093582/kekeringan-di-kota-bandung-akibat-musim-kemarau-begini-respon-cepat-fakultas-teknik-universitas-widyatama

2. Project Documentation Video: A comprehensive documentary video, showcasing the project's journey from equipment fabrication to community handover, has been produced and uploaded to YouTube. This visual narrative, capturing the essence of the project and its impact, is presented in Figure 7.

Figure 7. Video for Community Service Activities

3. Socialization and System Handover: The successful handover of the Greywater and RWH systems to RT and RW management, as depicted in Figure 8, marks a crucial phase in enhancing community engagement and ensuring direct benefits, reinforcing the collaboration between the Community Service Team (PKM) and local residents..

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Figure 8. Handover of Gray Water and RWH Equipment

4. Guidance Book RWH and Grey Water and Activity Poster: This project's deliverables include a user-friendly guidance book for Grey Water and Rain Water Harvesting (RWH) systems, alongside engaging posters for community service activities. The book comprehensively details operation, maintenance, and benefits of these systems, tailored for easy understanding by a diverse audience, regardless of their technical expertise. In parallel, the visually appealing posters aim to enhance community awareness and participation in the use and upkeep of these environmental systems, effectively communicating key project messages. The impact and utility of these materials are showcased in Figures 9 and 10.

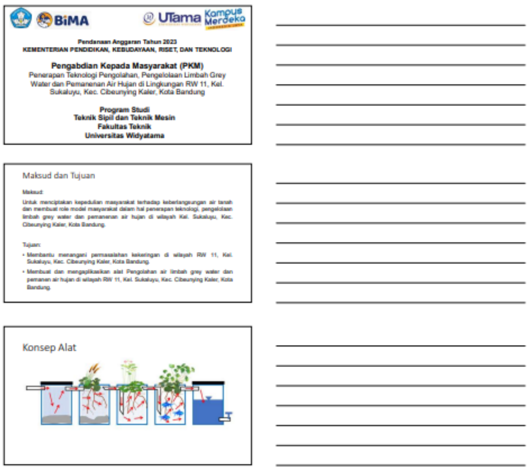

Figure 9. Guidance Book RWH and Grey Water

Figure 10. Posters for Community Service Activities

3.2 Output Response from Community and Discussion

In this section, we examine community reactions to the installation of Grey Water and Rain Water Harvesting (RWH) systems. Following outreach by the UTama Community Service Team, the community demonstrated a high level of understanding of both the Grey Water treatment device and the RWH system, as evidenced by scores of 4 and 5 on the Likert scale. This scale, ranging from 1 ("very little understanding") to 5 ("very good understanding"), highlights the community's comprehensive grasp of the technologies involved. Regarding the Grey Water Treatment Device, community feedback was overwhelmingly positive. A majority of respondents noted substantial benefits, underlining the device's effectiveness and utility in everyday life. This outcome not only signifies an advancement in environmental management but also tangible benefits for the users, showcasing the successful adoption and favorable reception of the technology. In terms of maintenance and promotion of the Grey Water Treatment and RWH systems, the community's willingness was notably strong. Most participants indicated a readiness to sustain and advocate for these systems, demonstrating a deep commitment to environmental sustainability and an understanding of efficient water resource management. This enthusiastic response underlines the project's significant role in fostering sustainable practices within the community. Post-implementation observations of the greywater and RWH systems have revealed notable enhancements in water quality. The greywater system, in particular, effectively processes household wastewater, reducing concentrations of both organic and inorganic contaminants. The resulting water, suitable for non-potable uses such as irrigation and cleaning, aligns with established water quality standards, offering a viable solution for both household and environmental applications. Conversely, the RWH system has shown efficacy in diminishing dependence on traditional raw water sources. By capturing, storing, and filtering rainwater, it provides a sustainable alternative, especially in water-scarce regions. The treated rainwater, deemed clean and safe, broadens its utility across various daily activities. The implementation of this system not only addresses water scarcity but also exemplifies the impact of efficient water resource management on environmental sustainability and community welfare.

4. CONCLUSION

In conclusion, this project has seen the procurement of additional materials for both the greywater and Rainwater Harvesting (RWH) units. The greywater unit required the addition of water purification media, such as activated sand, activated charcoal, and zeolite, while the RWH unit needed additional materials like iron and concrete brackets for tank placement. Furthermore, the installation of these units was tailored to the specific storage conditions, resulting in minor design variations that do not compromise their functionality. The placement of the greywater and RWH equipment within the RW 11 community closely adhered to the planned implementation method, with challenges addressed through discussions with local authorities on procedural and technical aspects. The first greywater unit has already proven beneficial to local food businesses, as greywater units can only be installed in commercial establishments and not in residential homes. However, the impact and benefits of the RWH unit remain unobservable due to the absence of rainfall. Looking ahead, future PKM initiatives in the RW 11 community could pivot towards addressing waste-related issues. Future recommendations include adapting unit installations to the local conditions and authorities, which may require coordination time. Additional materials and accessories used for the greywater and rainwater harvesting units should be tailored to the specific location where these units will be placed.

ACKNOWLEDGEMENT

We would like to express our gratitude to the Directorate of Research, Technology, and Community Engagement for the Research and Community Engagement Funding Grant in the 2023 Fiscal Year, with reference number 0557/E5.5/AL.04/2023, dated June 1, 2023.

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