NUSANTARA CIVIL ENGINEERING JOURNAL
Vol. 5 No.01 (2026) pp. 65-74

Eco – wudu': sustainable watering system by using wudu' water

Nik Erfan Haffey Bin Nik Man[1] , Siti Asmahani binti Mohamed[2]
[1,2] Politeknik Melaka.
asmahani@polimelaka.edu.my

Received 30-05-2026; revision date 20-06-2025, 22=06-2026

Abstract
The Eco-Wudu Sustainable Watering System project was developed to address the issue of clean ablution (wudu) water wastage at the Polytechnic Melaka Praying Room (surau). Daily ablution activities consume a substantial amount of water, most of which is discharged directly into the drainage system without being reused. This situation highlights the need for an efficient and sustainable water management system capable of recycling ablution water for secondary purposes, particularly landscape irrigation. The project employed a design and development methodology involving four phases: problem identification, system design, prototype development, and performance evaluation. An automated irrigation prototype was developed using an Arduino Uno microcontroller, a soil moisture sensor, a water storage tank, an automatic water pump, a uPVC gutter channel, and a solar panel as a renewable energy source. The system was installed at the surau and tested over a four-week period. Data collection involved measuring the volume of ablution water collected, soil moisture levels, irrigation frequency, and water consumption before and after implementation. The findings revealed that the system successfully collected an average of 80–100 litres of ablution water per day, which was subsequently reused for landscape irrigation. The soil moisture sensor effectively activated the irrigation system when moisture levels fell below the predetermined threshold of 40%, maintaining soil moisture between 40% and 70%. The reuse of ablution water reduced dependence on the main water supply by approximately 53%, resulting in significant water savings compared to conventional manual watering methods. In addition, the use of solar energy reduced electricity consumption and enhanced the overall sustainability of the system. In conclusion, the Eco-Wudu Sustainable Watering System provides an effective and environmentally friendly solution for recycling ablution water within institutional settings. The project contributes to sustainable water management, green engineering practices, and environmental awareness among the surau community. Future improvements may include the integration of a multi-stage water filtration system and Internet of Things (IoT)-based monitoring for real-time data collection, analysis, and remote system management.
Keywords: *Smart Irrigation System; Recycled Ablution Water; Arduino; Solar Energy; Absolute Error; Standard Deviation;*

1. Introduction

1.0 Introduction

Water is an essential natural resource that must be managed efficiently to ensure long-term sustainability. In mosques and prayer facilities, a considerable amount of clean water is used daily for ablution (wudu) before prayers. However, most of this water is discharged directly into drainage systems without being reused, leading to unnecessary water wastage. Studies have shown that ablution water is classified as greywater with relatively low levels of

contamination, making it suitable for reuse after minimal treatment. According to Al Mamun et al. (2014), ablution water generated in mosques possesses acceptable physical and chemical characteristics for non-potable applications such as landscape irrigation and toilet flushing. In addition, Hurayra (2024) found that the average amount of water used per ablution ranges between 4 and 8 litres, depending on user behaviour and awareness. This indicates that a large quantity of water can be conserved through proper management and reuse strategies. Therefore, the implementation of an ablution water recycling system is a practical solution to minimize water wastage and support sustainable development goals related to water conservation and environmental protection.

The Eco Wudu' Sustainable Watering System represents an engineering innovation developed to minimize water wastage through the reuse and optimization of available water resources. This system ensures that water is utilized efficiently, responsibly, and in an environmentally friendly manner, aligning with the principles of sustainable development. In this project, the Eco Wudu Sustainable Watering System was specifically designed to reuse clean wudu water for irrigating plants around the surau area. This initiative not only promotes water conservation but also supports green technology practices within sustainable resource management.

The system integrates several essential components, including Arduino Uno, soil moisture sensor, water pump, relay module, solar panel, rechargeable battery, uPVC gutter, water storage tank, and a mini-CCTV camera. Ablution water is collected via the uPVC gutters and directed into a storage tank. When the soil moisture sensor detects that the soil is dry, the Arduino activates the water pump to irrigate plants using the stored wudu water. The system is powered by solar energy, making it a renewable, energy-efficient, and environmentally sustainable solution.

The demand for the Eco Wudu Sustainable Watering System continues to rise in parallel with increasing public awareness of environmental sustainability and water conservation. Presently, many mosques and suraus face issues such as lack of staff, and limited maintenance resources. Based on survey and interview findings, it was observed that surau caretakers and gardeners encounter similar challenges. This project provides a practical and cost-effective solution by reusing clean ablution water for landscape irrigation, reducing both water wastage and operational costs.

In comparison, various automated irrigation systems available in the markets such as smart irrigation systems with rain sensors, drip irrigation systems, and sprinkler systems still depend on conventional water and electricity sources. The uniqueness of this project lies in its integration of green technology with Islamic values, reusing clean ablution water that would otherwise be wasted. Furthermore, the use of solar energy enhances efficiency, reduces energy costs, and promotes environmental sustainability. This project exemplifies a strong balance between engineering innovation, environmental stewardship, and religious significance, offering meaningful benefits to both the community and the environment.

1.2 Problem Statement

Water scarcity and inefficient water management have become major environmental concerns worldwide. Although ablution (wudu) water is generally clean and categorized as low-contaminated greywater, a significant amount of this water is discharged directly into drainage systems after use. In many mosques and prayer facilities, including those in educational institutions, there is no effective system to collect and reuse ablution water for beneficial purposes. As a result, a valuable water resource is wasted daily despite its potential for non-potable applications such as landscape irrigation. At Politeknik Melaka, a large volume of water is used for ablution by students and staff every day. Most of the used

ablution water flows directly into the drainage system without being reused, contributing to unnecessary water wastage and increased dependence on the main water supply for plant watering activities. Conventional irrigation methods rely entirely on treated water, which increases water consumption and operational costs while reducing overall sustainability.
Furthermore, manual plant watering practices are often inconsistent and may lead to overwatering or underwatering, affecting plant health and resulting in inefficient water use. The absence of an automated system to monitor soil moisture and regulate irrigation further limits the effectiveness of water conservation efforts.
Therefore, there is a need to develop an innovative and sustainable solution that can collect, store, and reuse ablution water efficiently. The Eco-Wudu Sustainable Watering System was developed to address this issue by integrating ablution water harvesting, automatic irrigation control, soil moisture monitoring, and solar-powered operation. This system aims to reduce water wastage, minimize dependence on the main water supply, and promote sustainable water management practices within the campus environment.

Figure 1.2 Dried soil and plants at Surau Ar- Raudah

1.3 Importance of Research

This research is important as it contributes to sustainable engineering innovation by demonstrating the reuse of wudu ' water for automatic irrigation. It introduces an effective method to reduce water wastage in surau and mosque environments, where large volumes of clean ablution water are usually discharged into drains without reuse. Through this project, wudu' water is collected, filtered, and redirected for irrigation, proving that it can serve as an alternative water source for landscape maintenance.
From an engineering perspective, this research provides valuable insights into the integration of IoT-based sensor systems and automated irrigation mechanisms. The soil moisture sensor plays a key role in ensuring efficient water distribution, where irrigation only occurs when the soil becomes dry. This approach not only enhances water-use efficiency but also supports the development of smart environmental systems that align with sustainable development goals.
In addition, this research highlights the practical application of data analysis in determining the performance and effectiveness of the system. Measurements of soil moisture levels and total water used were analysed to evaluate the system's reliability under real conditions. The findings contribute to future research and development in sustainable water recycling systems, offering potential applications in public institutions, residential areas, and agricultural settings. Overall, the Eco Wudu's Sustainable Watering System research emphasizes the importance of combining environmental awareness with engineering design,

providing a significant contribution to sustainable technology and water conservation practices.

2. Method

2.1 Sampling Techniques

The sampling techniques for this study were carried out by using two different sizes of pots, pot A (large) and pot B (small), with 15 pots A and 10 pots B. It is to know the amount of water needed for each pot. Both pots were tested by taking the amount of water pumped per hour, depending on the soil moisture. Besides, using questionnaires can help determine the effectiveness of the project, whether it can help solve the problems faced by cleaners, gardeners, and people who use the surau. In this project, the automatic irrigation system was programmed to activate when the soil moisture level falls below **40%** and stop watering when the moisture level reaches **60%**. This range was selected because it provides adequate moisture for landscape plants while preventing excessive water use. The use of soil moisture sensors ensures efficient irrigation management and supports sustainable water conservation practices through the reuse of ablution water.

2.2 Primary Data

The primary data collected in this study include measurements of water volume, questionnaire feedback, and field observations. Water usage was recorded daily to determine the total wudu' water collected and used for irrigation, with 57.9 liters used in the first week and 57.1 liters in the second week, resulting in a total of 115 liters from a 150-liter tank, leaving a balance of 35 liters that proved the water was sufficient for irrigation. A total of 10 respondents participated in this study, comprising 6 gardening staff, 2 supervisors, and 2 administrative personnel. The respondents were selected based on their experience and involvement in landscape maintenance and facility management to assess the system's effectiveness, with most respondents agreeing that the project successfully reduced manual watering tasks, reused wudu' water efficiently, and supported healthy plant growth. In addition, field observations were conducted throughout the project to monitor system operation, irrigation frequency, and environmental conditions such as day and night performance, providing an overall understanding of the system's functionality and reliability in real conditions.

2.3 Secondary data

The secondary data for this project were obtained from various published journals and research papers related to smart irrigation systems, greywater reuse, and soil moisture sensor technologies. Previous studies, such as those by Kumari and Sah (2021) highlighted the role of IoT-based smart irrigation in improving water efficiency and monitoring soil conditions. Similarly, Pinto and Maheshwari (2010) emphasized the benefits and community perceptions of reusing greywater for irrigation, particularly in residential and institutional settings. Dwipayana and Wohir (2023) discussed the effectiveness of soil moisture sensors in optimizing water usage for sustainable agriculture, while Millán et al. (2024) evaluated the accuracy and reliability of commercial sensors for automated irrigation systems. In addition, other studies on the quantification of greywater reuse benefits (2020) further supported the potential of sustainable water management in reducing wastage and conserving natural resources. Altogether, these secondary sources provide a strong foundation for

understanding the concepts, technologies, and environmental impacts relevant to the Eco Wudu' Sustainable Watering System project.

3. Results and Discussion

To achieve the research goals, data analysis of relevant information was carried out. The data to be collected will likely include the amount of water recycled, the volume of piped water saved, the level of energy produced by solar panels, and the power consumption of the system components. It is expected that the solar energy will be sufficient to operate the pump and soil moisture sensors, showing the feasibility of the system in areas without a stable electricity supply. Furthermore, comparisons between traditional watering methods and this sustainable system may indicate a reduction in operational costs. However, potential limitations such as limited storage tank capacity and cloudy weather can affect solar efficiency.

3.1 Analysis of Water Waste before the project was developed

An analysis of wudu ' water quantity was conducted to determine the potential amount of water that can be collected and reused for irrigation. Based on the experiment, everyone uses about 0.2 liters of water per wudu'. Data collection was carried out by performing wudu', collecting the used water, and measuring it with a measuring cylinder for accuracy. Table 3.1 shows the observations over two weeks during zuhr and asr prayer times showed total water collection of 238 liters in week 1 and 244 liters in week 2, with only slight variation due to daily differences in worshipper numbers. This indicates that although the amount of water used per person is small, the accumulated total over time is significant.

Table 3.1 Shows water wasted before project was developed.

Weeks	Day	No. of	Est. water used	Total water used
1	Monday	25	2.0	50
	Tuesday	28		56
	Wednesday	32		64
	Thursday	22		44
	Friday	12		24
2	Monday	24	2.0	48
	Tuesday	27		54
	Wednesday	35		70
	Thursday	23		46
	Friday	13		26
Total		**∑ 241**		**∑ 482**

3.2 Analysis of Water Used for Irrigation

Table 3.2 Shows irrigation frequency for plant A and plant B.

Week	Type of Plant	Time for Irrigation Frequency								Total Water Used for Irrigation (Liter/Week)
		2pm – 5pm	5pm – 8pm	8pm – 11am	11am – 2am	2am – 5am	5am – 8am	8am – 11pm	11pm – 2pm	
1	Plant A (0.2L)	35	21	21	21	21	35	35	40	38.8
1	Plant B (0.1 L)	28	15	14	14	14	32	34	40	19.1
					Total Week 1					**57.9**
2	Plant A (0.2 L)	33	14	13	13	14	34	35	39	39
2	Plant B (0.1 L)	30	10	12	12	11	33	34	38	18.1
					Total Week 2					**57.1**
					Average Water Used for Irrigation (Liter/Week)					**57.5**

Table 3,2 shows that the IoT-based irrigation system effectively managed the release of recycled ablution water for both plants throughout the two-week period. Plant A used a total of 38.8 liters in Week 1 and 38.0 liters in Week 2, while Plant B used 19.1 liters and 18.1 liters respectively, giving a combined total of 115 liters with average water usage irrigation is 57.5 liters. The data indicates consistent water usage and stable system performance. Irrigation was more frequent during the afternoon (2–5 pm) and early morning (5–8 am), when soil moisture levels were lower due to higher evaporation rates. The slight decrease in total water usage from Week 1 to Week 2 suggests improved soil moisture retention and efficient control by the IoT system. From table 3.1 and 3.2 shows that the volume of recycled ablution water exceeded the daily irrigation demand, providing a sufficient and sustainable water source for plant watering. The surply water could also be stored for future use during dry periods. Overall, the results demonstrate that the Eco-Wudu system operated efficiently and maintained adequate irrigation performance while maximizing the reuse of treated ablution water.

3.3 Analysis Comprison of Conventional Water Usage before and after Eco-Wudu Implementation

Table 3.3 Shows Comprison of Conventional Water Usage before and after Eco-Wudu Implementation

Week	Conventional Water Usage (liter/week)	Eco wudu Recycled Water for Irrigation (liter/week)	Water Saved (liter/week)	Reduction (%)
Week 1	118	57.9	60.1	50.93
Week 2	124	57.5	66.5	53.63
Average Conventional Water Usage before and after Eco-Wudu Implementation (liter/week)				**52.28**

Table 3.3 indicates that the Eco-Wudu Sustainable Watering System significantly reduced the reliance on the conventional water supply. During Week 1, the conventional irrigation system consumed 228 litres of water, whereas the Eco-Wudu system required only 118 litres from the main supply, resulting in a saving of 60.1 litres (50.93%). Similarly, in Week 2, water consumption decreased from 124 litres to 57.5 litres, achieving a saving of 66.5 litres (53.63%). Overall, the system reduced the use of conventional water by an average of 52%, demonstrating its effectiveness in promoting sustainable water management practices.

3.3 Analysis of Effectivess of Eco Wudu`

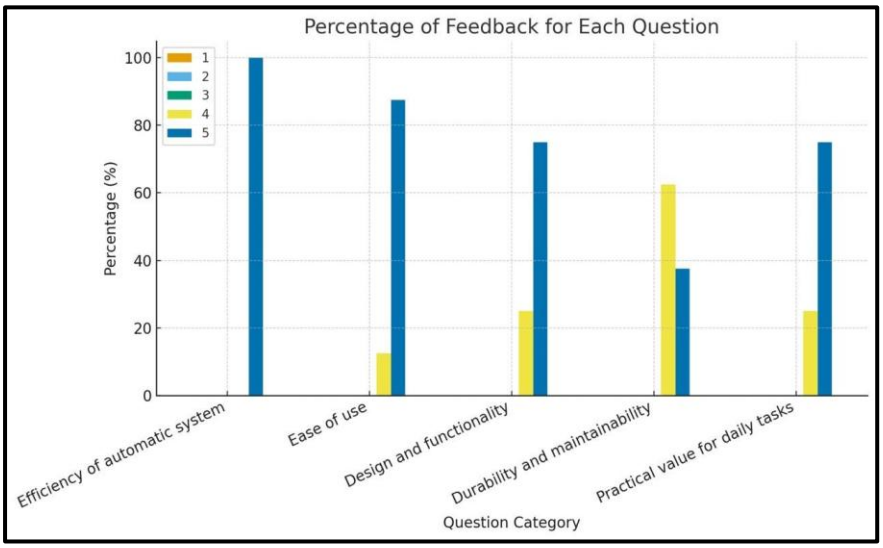

Figure 3.1: The effectiveness of project from questionnaires.

Figure 3.1 shows the effectiveness of the project from the questionnaires. A total of 10 respondents participated in this study, comprising 6 gardening staff, 2 supervisors, and 2 administrative personnel. The respondents were selected based on their experience and involvement in landscape maintenance and facility management. Their feedback was used to evaluate the performance, user-friendliness, and effectiveness of the Eco Wudu' Sustainable Watering System. Based on the results, most respondents rated the performance of the project very positively. The efficiency of the automatic system received a perfect score, with 100% of respondents giving the highest rating. For ease of use, 87.5% rated it as excellent while 12.5% rated it as good, showing that the system is generally user-friendly and easy to operate. In terms of design and functionality, 75% of respondents rated it as excellent and

25% as good, indicating that the system's structure and operation are both practical and effective.
Meanwhile, durability and maintainability obtained slightly more balanced responses, with 62.5% of respondents rating it as good and 37.5% as excellent. This suggests that while the system is durable, there is room for improvement in maintenance aspects. Lastly, the practical value in daily use achieved 75% excellent and 25% good ratings, proving that the system provides clear benefits for sustainability and daily operations.

4. Conclusion

In conclusion, the analysis of wudu' water quantity has proven that the Eco Wudu' Sustainable Watering System has great potential in promoting sustainable water management. Even though each individual uses a relatively small amount of water during ablution, the accumulated volume over time is significant and can be effectively reused for irrigation purposes. The results showed that a total of 238 liters and 244 liters of water were collected in two consecutive weeks, indicating a consistent and reliable alternative water source for landscape irrigation. This finding supports previous studies which reported that ablution water possesses low contamination levels and can be reused for non-potable applications such as irrigation and landscaping (Al Mamun et al., 2014). The development of the Internet of Things (IoT)-based monitoring and control system further enhanced the effectiveness of the project. By integrating soil moisture sensors, a microcontroller, and an automatic water pump, the system was able to continuously monitor soil conditions and perform irrigation only when required. This real-time monitoring capability improved water-use efficiency by preventing over-irrigation and ensuring that plants received an adequate amount of water based on actual soil moisture levels. The automation process also reduced the need for manual watering and contributed to more sustainable landscape maintenance practices.
The irrigation data collected using the IoT-based system also demonstrated that the system functions efficiently and effectively. The automatic irrigation mechanism released an average of 57.5 liters of water per week while maintaining suitable soil moisture levels for plant growth. The slight reduction in total water usage from the first to the second week reflected improved soil moisture retention and more efficient irrigation scheduling. This finding is consistent with recommendations that maintaining soil moisture within an optimum range can improve irrigation efficiency and plant health while reducing water wastage (Allen et al., 1998; USDA NRCS, 2019).
Furthermore, the questionnaire analysis supports the success of this project. Most respondents rated the system highly in terms of efficiency, user-friendliness, and practicality. With 100% of respondents rating the system's efficiency as excellent, it is evident that the Eco Wudu' Sustainable Watering System meets user expectations and achieves its intended objectives. The positive feedback also aligns with previous studies highlighting the importance of innovative water recycling technologies in enhancing environmental sustainability and resource conservation (Shaikh Salim et al., 2015; Ameer et al., 2025). Therefore, it can be concluded that the Eco Wudu' Sustainable Watering System successfully achieves its goals by promoting sustainable water management, improving water-use efficiency, and providing an innovative solution for environmentally friendly irrigation in surau environments. The implementation of such systems can contribute to water conservation efforts, reduce dependence on treated water supplies, and support the

achievement of sustainable development goals related to responsible water consumption and environmental protection (FAO, 1998; Ameer et al., 2025).

Acknowledgment

I would like to express my deepest gratitude to Allah SWT for His blessings, guidance, and strength, which enabled me to successfully complete this research paper.
I would like to extend my sincere appreciation and heartfelt thanks to my supervisor, Ms Siti Asmahani Binti Mohamed, for the invaluable guidance, continuous support, constructive comments, and encouragement provided throughout the completion of this study. Their expertise, patience, and dedication have greatly contributed to the successful completion of this research and have enhanced my understanding of the research process. I would also like to express my gratitude to all lecturers, respondents, and friends who have directly or indirectly contributed their time, knowledge, and assistance during the conduct of this study. Their cooperation and support were essential to the successful completion of this research.
Special thanks are extended to my family for their endless love, prayers, understanding, and moral support throughout my academic journey. Their encouragement has been a constant source of motivation and inspiration. Finally, hope that this research will contribute meaningfully to the existing body of knowledge and serve as a useful reference for future studies.

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