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A Case Study of Assessing Sustainable Water Resource Management Strategies at a community mosque; Masjid Al-Ehsaniah Port Dickson

Nur Syamimi Rusli[1,*], Nur Hidayah Moktar[1], Zulkurnain Hassan[1]

[1] Department of Electrical Engineering, Politeknik Port Dickson, KM 14, Jalan Pantai, 71050 Si Rusa, Negeri Sembilan, Malaysia

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ABSTRACT

Efficient water usage in places of worship such as mosques is a crucial aspect of water resource management to ensure sustainability and reduce wastage. This study aims to analyze water flow rates at five main locations in Masjid Al-Ehsaniah, Taman Intan Perdana, identify differences in water flow between ablution areas, toilets, and the dining area, and propose measures to enhance water usage efficiency. Data was collected by monitoring water flow rates at each location over a 50-second period, recorded at 5-second intervals. Results showed that both female and male ablution areas recorded the highest flow rates, increasing steadily from 3.7 L/s and 2.5 L/s at the 5-second mark to 15.5 L/s and 15.3 L/s at 50 seconds. In contrast, the male toilet had the lowest flow rate, with only 0.3 L/s at 5 seconds, gradually increasing to 3.7 L/s at 50 seconds. These differences indicate that ablution areas are the primary water usage points in the mosque and could result in wastage if not properly controlled. Based on the findings, several recommendations were made to improve water usage efficiency, including installing automatic sensors on ablution taps, using water pressure control systems, regular maintenance to prevent leaks, and awareness campaigns for congregants on the importance of water conservation. These measures not only help reduce wastage but also support compliance with the Energy Efficiency and Conservation Act 2024 (EECA), which emphasizes efficient water usage in public spaces. This study contributes significantly to mosque water management by offering a data-driven approach to enhance resource usage effectiveness. Further research is recommended to explore the impact of smart technologies in automatically controlling water flow and improving water supply systems in places of worship.

1. Introduction

1.1 Background

These Efficient water usage in places of worship like mosques is an important aspect of water resource management. Mosques function as places of worship frequently visited by congregants, particularly for ablution, toilet use, and food preparation. Therefore, monitoring and analysing water

* *Corresponding author.*
E-mail address: syamimi@polipd.edu.my

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flow rates at key locations in the mosque can help identify usage patterns and offer recommendations to improve the water supply system. Efficient water usage can not only reduce wastage but also ensure a continuous and adequate supply of water for daily needs.

According to a study by Zulkifli et al. [5], water usage in mosques can reach high levels, particularly during obligatory prayer times and Friday prayers. The study also suggested that automatic control systems such as water flow sensors can reduce wastage. Furthermore, a study by Rahman & Abdullah [4] found that there are imbalances in water pressure in different parts of mosques, leading to inconsistent water usage. This highlights the need for regular maintenance to ensure optimal water pressure. In addition, a report by the Ministry of Water and Natural Resources Malaysia emphasized the need for sustainable water management in all public buildings, including mosques, to ensure long-term national water resource sustainability.

Factors such as pipe system design, water pressure, and the number of users also play crucial roles in determining water flow rates in mosques. Mosques with many congregants are likely to experience high water usage, especially during peak times such as before Friday prayers and Tarawih prayers in Ramadan. Hence, this study is essential to identify the needs and improvement measures to ensure more efficient water usage.

1.2 Definition Term

To better understand this study, several key terms are defined as follows. Water flow rate refers to the amount of water flowing through a pipe within a specific period, usually measured in Liters per second (L/s). Water usage refers to the amount of water used over a period for a specific activity or location, such as toilets, ablution areas, or dining areas.

Water pressure is the force that drives water through pipes and can influence the flow rate. High pressure can lead to wastage, while low pressure can hinder smooth water usage. Water wastage refers to inefficient water usage, whether due to leaks, uncontrolled flow, or excessive use without necessity.

Water control systems include mechanisms such as valves, sensors, and pumps used to control water flow and pressure to ensure more efficient usage. Understanding these concepts provides a clearer picture of how water flow rate affects water usage in mosques and how it can be optimized to prevent wastage and promote sustainable usage.

1.3 Problem Statement

There are several challenges in water management in mosques that can lead to wastage and imbalance in water usage. One major issue is the inconsistent water flow rate between pipe locations in mosques. Differences in water pressure between toilets, ablution areas, and the dining area can lead to inefficient usage, with some areas experiencing wastage due to high pressure while others face insufficient supply. This situation not only affects user comfort but can also increase water bills for mosque management.

Additionally, water wastage often occurs due to excessively high pressure or inefficient control systems. According to Hassan et al. [12], mosques without smart water control systems tend to experience higher wastage, especially during peak times like before congregational prayers. Furthermore, lack of regular maintenance causes damaged pipes or valves to go unrepaired, contributing to unnecessary water loss. This underscores the need for modern technologies such as flow sensors and pressure monitoring systems to reduce wastage.

The lack of empirical data on water usage patterns in mosques also presents a challenge in formulating effective water-saving strategies. A study by Ismail & Tan [9] revealed that most mosques lack monitoring systems to record water usage by location. Without accurate data, it is difficult to plan specific improvement actions to optimize usage. Therefore, this study analyses water flow rates at Masjid Al-Ehsaniah, Taman Intan Perdana, focusing on five key locations: female toilet, female ablution area, male ablution area, male toilet, and dining area.

In a broader context, this study also aligns with the Energy Efficiency and Conservation Act 2024 (EECA), which emphasizes the importance of sustainable energy and water resource management, including the use of energy-efficient technologies in water supply systems. According to EECA, all public buildings are encouraged to implement water monitoring and control systems to reduce wastage and increase resource usage efficiency. Hence, the results of this study not only assist the management of Masjid Al-Ehsaniah in planning better water strategies but also align with national initiatives to preserve water resources for the long term.

1.4 Objectives of Study

This study aims to achieve the following objectives:

a. Analyze water flow rates at five main locations in the mosque.
b. Identify differences in water flow between ablution areas, toilets, and the dining area.
c. Provide recommendations to improve water usage efficiency in the mosque.

1.5 Significance of Study

The findings of this study are expected to benefit mosque management in planning more sustainable water usage strategies. Additionally, the results may serve as a reference for other institutions facing similar water management challenges.

2. Literature review

The literature review plays a vital role in providing deeper insight into water management in mosques, water flow rates, and water-saving measures relevant to the Energy Efficiency and Conservation Act 2024 (EECA). This section discusses previous studies related to water usage in mosques, the importance of water efficiency, and factors influencing water flow rates. It also explores best practices in water management and technologies that can enhance water efficiency in mosques.

2.1 Water Usage in Mosque

Mosques are centre of worship with high water demands, particularly for ablution, toilet use, and food preparation. Zulkifli et al. [5] reported that water usage in mosques spikes significantly during obligatory prayers, Friday prayers, and Ramadan. The study found that water usage in female ablution areas was higher than in male areas due to differences in duration and water usage practices. Moreover, Rahman & Abdullah [4] observed that uneven water pressure in some mosques led to inconsistent flow rates and ultimately water wastage.

A separate study by Ibrahim et al. emphasized that mosque location and capacity play important roles in determining water usage volume. Urban mosques tend to consume more water than those in rural areas due to larger congregations and more modern facilities. Additionally, mosques with

efficient pipe designs exhibited more controlled water usage compared to those using conventional systems.

2.2 Importance of Water Efficiency in Mosque Management

According to the Ministry of Water and Natural Resources Malaysia, religious institutions like mosques must adopt water efficiency measures to prevent wastage and ensure adequate supply. One suggested measure is the installation of automatic sensors to control water flow in ablution areas. Furthermore, the Energy Efficiency and Conservation Act 2024 (EECA) highlights the importance of sustainable water and energy usage in all sectors, including public and religious buildings (Energy Commission Malaysia, 2024). Hasan et al. supported this initiative by recommending the use of water-efficient tools like low-pressure taps and greywater recycling systems to reduce wastage.

Ahmad et al. noted that water efficiency not only reduces wastage but also decreases mosque operational costs in the long term. Mosques implementing water recovery systems such as reusing ablution water for landscape irrigation which reported up to a 30% monthly reduction in water usage. Additionally, Latif et al. [9] suggested green technologies in mosque water systems, such as rainwater harvesting tanks and wastewater filtration systems, to ensure sustainable water resource continuity.

2.3 Factors Influencing Water Flow Rate

Several key factors influence water flow rate, including pipe system design, water pressure, and number of users. Smith et al. found that excessively high pressure can lead to wastage, while low pressure can disrupt smooth water usage. Wong & Tan demonstrated that adjustable flow control valves could improve water efficiency in public buildings. Furthermore, Jamaludin et al. identified pipe leaks as a major contributor to water wastage in Malaysian mosques and public institutions.

Weather also plays a role in water usage. Chong et al. reported that mosques in hot and dry areas require more water for air conditioning and landscape maintenance compared to those in temperate regions. Omar et al. found that mosques hosting large numbers of congregants during festive seasons or events experience sudden water usage surges, potentially straining the supply system if not properly managed.

3. Methodology

3.1 Research Design

A quantitative approach was employed to measure water flow rates at five primary locations within the mosque: the female toilet, female ablution area, male ablution area, male toilet, and dining area. The collected data was analysed to identify water usage patterns, flow rates at each location, and contributing factors to water usage.

3.2 Study Location

The study was conducted at Masjid Al-Ehsaniah, Taman Intan Perdana, chosen due to its high congregant attendance, especially during obligatory and Friday prayers. The study focused on five key water usage locations:

- Pipe A: Female toilet
- Pipe B: Female ablution area (outdoor)

- Pipe C: Male ablution area (outdoor)
- Pipe D: Male toilet
- Pipe E: Dining area

3.3 Data Collection Method

Data was collected experimentally using a water flow measuring device to record the volume of water flowing over a set period. Measurements were taken at specific intervals (5 to 50 seconds) to observe the trend in flow rate changes. Data collected included:

- Total Liters of water flow within specific time intervals.
- Differences in flow rates across locations.
- Factors affecting flow rate variations such as water pressure and user activity.

3.4 Data Analysis Techniques

Descriptive statistical methods were used to determine the average water flow rate at each location. Analytical techniques included:

- Mean and standard deviation: To identify differences in flow rates across locations.
- Location comparisons: To determine which area had the highest and lowest water usage.
- Water usage trend analysis: To observe usage pattern changes over the study period.

3.5 Data Validity and Reliability

To ensure data accuracy and reliability, the following steps were taken:

- Use of calibrated measuring instruments.
- Data collection under normal conditions without external interference such as leaks or supply interruptions.
- Repetition of measurements at different times to ensure data validity.

3.6 Study limitations

This study had several limitations, including:

- It was conducted at a single site (Masjid Al-Ehsaniah), which may not represent usage patterns at other mosques.
- External factors such as weather changes and inconsistent congregant attendance could influence results.
- Measurements were taken during specific times rather than continuously throughout the day.

This research methodology enabled the researchers to obtain accurate data on water flow rates in the mosque and identify improvement measures that can enhance water usage efficiency in places of worship.

4. Results

4.1 Analysis of Water Flow Rate at Five Key Locations in the Mosque

The analysis of water flow rates was conducted at five main locations in Masjid Al-Ehsaniah. The total water usage over a 50 second period was recorded and is summarized in Table 1.

Table 1
Total Water Consumption in 50 Seconds by Pipe

Bil	Time, second (S)	Pipe A (Female Toilet)	Pipe B (Female Ablution Area)	Pipe C (Male Ablution Area)	Pipe D (Male Toilet)	Pipe E (Dining Area)
1	5	1.2	3.7	2.5	0.3	1.3
2	10	2.9	4.7	3.6	0.8	1.9
3	15	3.6	6.1	5.1	1.1	2.5
4	20	4.9	6.8	6.5	1.5	3.1
5	25	6.3	8.3	8.0	1.8	3.7
6	30	7.5	9.8	9.8	2.3	4.1
7	35	8.7	11.2	10.9	2.6	4.6
8	40	9.9	12.7	12.4	3.0	5.1
9	45	11.2	14.1	13.8	3.3	5.7
10	50	12.5	15.5	15.3	3.7	6.3

The analysis from Table 1 indicates that the female (Pipe B) and male ablution areas (Pipe C) recorded the highest cumulative water usage, reaching 15.5 Liters and 15.3 Liters respectively at the 50 second mark. This is consistent with their function, as ablution is performed before each prayer, especially during peak periods such as Friday prayers.

Pipe A (Female Toilet) also showed a steady increase in water flow, beginning at 1.2 Liters and rising to 12.5 Liters by the end of the observation period. Although not as high as the ablution areas, this usage is significantly higher than the male toilet (Pipe D), indicating that female toilet facilities may be used more frequently or for longer durations. This may reflect differences in usage behaviour, the number of fixtures, or overall visitor patterns.

In contrast, Pipe D (Male Toilet) recorded the lowest usage, starting at 0.3 Liters and increasing to 3.7 Liters, possibly due to fewer users or more efficient water usage. The dining area (Pipe E) showed moderate flow, rising from 1.3 to 6.3 Liters over 50 second, likely reflecting intermittent water use for cleaning or food-related activities.

This variation in water usage highlights the need for tailored water-saving strategies at each location. As reported by Zulkifli et al. [5], ablution areas generally see the highest consumption, requiring the implementation of smart control systems. Additionally, Rahman and Abdullah [4]

emphasized the influence of water pressure inconsistencies in different parts of a building, which can lead to water imbalance and wastage.

The findings support the call for real-time monitoring and pressure regulation in mosque water systems, in line with the Energy Efficiency and Conservation Act 2024 (EECA), which encourages sustainable water management in public facilities.

4.2 Differences in Water Flow Between Ablution Areas, Toilets, and Dining Area

The comparison of water flow between the ablution areas, toilets, and the dining space shows significant variation. The male and female ablution areas recorded the highest average water usage, with 9.14 Liters, compared to 4.56 Liters in toilets and 4.22 Liters in the dining area, as shown in Table 2.

Table 2
Average Consumption of Water (Liters) by Category

Category	Average Consumption of Water (Liters)
Ablution Area (B & C)	9.14
Toilet (D)	4.56
Dining Area €	4.22

The higher usage in ablution areas is attributed to the frequent and longer duration of water use, especially before congregational prayers. Zulkifli et al. [5] noted that water usage at ablution areas can be reduced with the installation of low-pressure taps or smart water control systems. The Ministry of Water and Natural Resources Malaysia (2021) has also emphasized the importance of efficient water technologies in public buildings to reduce wastage.

This study aligns with the Energy Efficiency and Conservation Act 2024 (EECA), which promotes efficient use of water and energy resources in public facilities. Therefore, installing water-efficient taps and automated flow control systems is recommended to improve water management at the mosque.

4.3 Recommendation for Improving Water Efficiency at the Mosque

Based on the data analysis, the following key recommendations are proposed:

- **Installation of Automatic Water Flow Sensors**
  Integrate sensors in taps at ablution and toilet areas to reduce unnecessary water usage. These sensors align with green technology practices widely adopted in public facilities.

- **Use of Low-Pressure Taps**
  Replace high-pressure taps to prevent excessive and uncontrolled water flow while maintaining user comfort

- **Balanced Water Pressure System**
  Adjust water pressure across the mosque to avoid imbalance that leads to either waste or insufficient supply.

- **Routine Maintenance**

Perform regular checks to detect leaks or damage, which, according to Ali et al. (2022), can reduce water usage by up to 30%.

- **Greywater Reuse System**
  Recycle uncontaminated wastewater for non-potable uses like cleaning and plant irrigation, reducing the need for fresh water.

These actions support EECA 2024 objectives and offer a sustainable approach to mosque water management through a combination of technology, maintenance, and behavioural change.

4.4 Discussion

The study successfully met its objectives:

- **Objective 1**: Found significant variation in water flow rates, with the highest usage in ablution areas due to frequent prayer-related activities.
- **Objective 2**: Ablution areas used significantly more water compared to toilets and the dining area, confirming findings by Zulkifli et al. [5].
- **Objective 3**: Proposed strategies such as sensor installation, pressure control, and awareness campaigns—all aligned with EECA 2024 to promote sustainable water usage in religious facilities.

5. Conclusion

This study analysed water flow in five key locations at Masjid Al-Ehsaniah and identified high water consumption in ablution areas. Several strategies were recommended, including sensor installations and educational campaigns. Implementing these measures can enhance water efficiency and align the mosque's operations with sustainable resource management principles outlined in EECA 2024.

6. Recommendation

Future studies should:

- Involve a larger number of mosques for broader comparison.
- Utilize IoT-based monitoring for real-time, detailed water usage data.
- Assess user awareness and conservation behaviour via surveys or interviews.
- Investigate the effectiveness of implemented water-saving strategies at other mosques.

These improvements would provide more practical and scalable recommendations for water efficiency in places of worship across Malaysia.

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