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# Conventional Water Filter (Sand and Gravel) for Ablution Water Treatment, Reuse Potential, and Its Water Savings

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**Abstract**

Ablution process consumes a huge amount of water especially in mosques for cleaning certain part of the body before performing prayers. The high volume of ablution water produced in mosques and its low strength in quality makes it a feasible option to be reused. This paper introduced an assessment of conventional filtration (sand and gravel) in treating ablution water for reuse purposes and its water savings potential in mosques. The treatment system has assessed its capability for reuse and its water savings potential. A pilot scale of filtration system was developed and was run with the ablution water from the Parit Raja mosque and the Pintas Puding mosque. The samples were taken during Friday noon prayer between January to March 2013. The efficiency of the conventional filtration system was tested for the effluent quality of $NH_3$, TSS, COD, and BOD. The case study of water savings estimation for the proposed system was undertaken at Pintas Puding mosque. It was determined based on the quantity of ablution water, water consumption, water demand, and water bills record. The results deduced that the conventional sand filtration can improve the water quality parameters; 0.60-0.05mg/L reduction of nitrogen ammonia ($NH_3$), 6.0-1.53mg/L of suspended solids (TSS), 3.12-0.15mg/L of chemical oxygen demand (COD), and 27.67-4.16mg/L of biochemical oxygen demand (BOD). The treatment system was projected to save water consumption by 41.73% and RM180.16 of water saving per month. Water consumption was estimated to be further reduced to 50.83% if reused activities such as irrigation and toilet flushing were applied. Hence, annual water savings could reach up to RM2161.92 per year. With the current instability of water resources, the implementation of the conventional filtration system for ablution water in the mosques provides water security and water resources conservation option for the country.

**Keywords:** ablution, quality, treatment, sand, gravel, water savings

## 1. Introduction

The interests in reusing ablution water in most arid and semi-arid countries have been heightened due to the increase of water demand, water shortage, and prolong drought. This practice has become increasingly common in Saudi Arabia and Yemen with the installation of treatment system to reuse the greywater generated from hand and mouthwash (ablution) in most of their mosques. Ablution water is the water which has been used by worshippers in washing (wudhu) before performing prayers. Ablution involves cleaning certain part of the body with fresh water in a certain order as a religious right. A large amount of greywater is produced in the mosque from ablution activity. High amount of greywater is produced in more than 700000 mosques in Indonesia due to the large number of Muslims (Uteberta et al., 2011).On the other hand, water-rich countries have less value in reusing the ablution water due to the fact that they have water security from the rainfall. However, early this year, Malaysia faced water shortage which affected more than seven million consumers in Klang Valley in which resulted in the reduction of water level at Sungai Selangor dam. This indicated that even though Malaysia has been blessed with high rainfall, there is no guarantee for constant water supply. This issue has put into remark the importance of water conservation. Muslim countries such as Indonesia, Malaysia or Middle East countries can be ascertained that ablution water and mosques are one of big sources of greywater in the country (Uteberta et al., 2011).

In Malaysia, the ablution water from mosques is commonly discharged directly into drainage channels without treatment. Under certain circumstances, ablution water is combined with stormwater run-off into the waterways and carries pollutants subsurface into the water surface. Generally, ablution water is less contaminated but it still

contains small amount of microorganisms mainly from gargling. *E. coli* concentration of 0.92CFU/100 mL was found in ablution water, and this showed low pathogenic level (Al-Wabel, 2011). The ablution water generated from mosques and community halls may contain organic compounds and chemicals. The ablution water generated from the mosques was found to be in low strength because the pH varied between 6.92-7.10, COD varied between 51-60 mg/L, BOD varied between 1.0-21 mg/L, TSS varied between 5-146 mg/L, and turbidity varied between 4.90-14.8 mg/L (Al-Jarallah, 2009). Therefore, basic treatment of greywater from mosques can be recycled and then reused in non-potable water applications (Suratkon et al., 2014). This practice has the tendency to reduce the water quality parameters in river when the source of water supply comes from the river.

Several studies were conducted particularly on greywater, but as of today, there are only limited research focusing on the greywater from ablution, treatment, and reuse issues (Al-Wabel, 2011), (Jamrah et al., 2004), (Al-Mughalles et al., 2012) and (Al-Jarallah, 2009). In Oman, a research was conducted to determine the variations in the quality and quantity of greywater produced at two mosques (Prathapar, 2004). The average daily production was 1.47 $m^3$ or 1470 L. Greywater production was also found to surge during the weeks when the mosque hosted a community event. While in Egypt, the average volume of water resulted from the process of ablution was about 5.37 L per person (Eriksson et al., 2003). In Yemen, a study was conducted by counting the worshippers who perform ablution for each of five prayers (Al-Mughalles et al., 2012). The result showed that the water quantity used by one worshipper during ablution was about 2.7 L/worshipper/one prayer for each mosque and the maximum value of water used was during the Friday prayer.

In recent years, even in countries with substantial water resources, the excessive use of water has affected the availability of the resources (Hamilton et al., 2007). In Malaysia, there are no in-depth studies about the ablution that can provide a clear understanding on how the ablution water is being reused with minimal treatment in mosques. However, the water cascade analysis (WCA) technique was adapted to establish the minimum water and wastewater targets for Sultan Ismail mosque at University Teknologi Malaysia (UTM). The targets generated via WCA have predicted significant potential reductions in terms of fresh water and wastewater, far beyond the potential reductions calculated after a detailed water network revamp on the mosque proposed by a research group at UTM (Manan et al., 2011). Based on the results, the research estimated about 85.5% freshwater and 67.7% wastewater reductions. By considering the benefits that can be derived from ablution greywater, thus the aim of this study is to incorporate the water savings benefit and the reduction of pollutants using a proposed efficient conventional treatment of sand and gravel.

## 2. Materials and Method

### *2.1 Ablution Water Treatment with Conventional Filtration*

Figure 1 shows the schematic diagram of ablution greywater treatment and the reuse system with conventional sand and gravel filtration. Ablution greywater from ablution bay entered the first water tank by gravity. The pump led the ablution greywater through a conventional filter and was stored in the water tank for reuse purposes; toilet flushing or water irrigation in the garden. The system was proposed to be installed in a mosque to achieve the estimated water saving and reuse for on-site application.

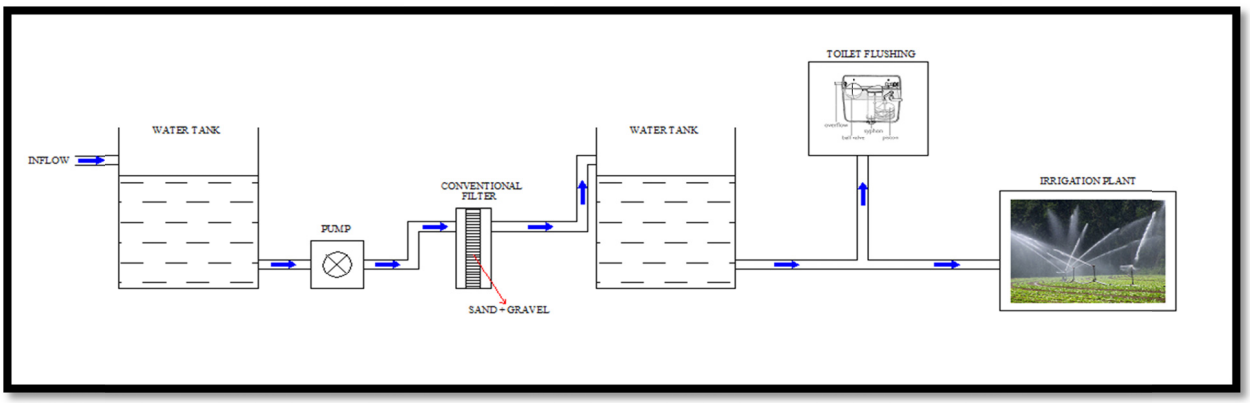


Figure 1. The schematic diagram of theablution water treatment in the pilot scale study

### *2.2 Sampling and Preservation of Ablution Water*

The samples of ablution water were taken from two mosques; the Parit Raja mosque (coordinate N 2°13'30" E

102°44'27") and the Pintas Puding mosque (coordinate N 1°51'29" E 103°5'58") which were located in Parit Raja Town, 20 km from the main city of Batu Pahat, Johor Malaysia. Ablution water sampling was taken on 28$^{th}$February 2014, 7$^{th}$ Mac 2014, and 14$^{th}$ Mac 2014 by applying the grab technique at a fixed time which was 1.00 pm before the Friday prayer. These sites were chosen due to the number of worshippers preferred its strategic location where it is in the heart of Parit Raja Town, and near the university residents of Universiti Tun Hussein Onn Malaysia. Grabbed samples were obtained by filling a container of ablution water at a specific point and time. Therefore, the grabbed samples collected should be representing the ablution water that was flowing out through the drainage. Ablution water was collected in the container until it was full and then was neatly closed so that no air enters the vacant space. Samples were then kept in an ice container to control the temperature and were brought immediately to the laboratory for testing.

The preparation and preservation of the sampling container were carried out according to the Standard Method for Examination of Water and Wastewater (APHA, 2005). Raw ablution water was collected and the analyses for the following parameters were conducted: pH and conductivity by pH meter; total suspended solids (TSS) by the gravimetric method; biological oxygen demand ($BOD_5$) by five-day test; chemical oxygen demand (COD) by using COD reflux method(reactor digestion method), and nitrogen ammonia ($NH_3$) by the Salicylate method (reactor digestion method).

*2.3 The Estimation of water savings*

Water savings estimation was calculated based on the proposed treatment system. The water savings estimation used the Pintas Puding mosque as the case study.

- Determination of the number of worshippers

  Worshippers who perform the ablution were calculated in each prayer (five times a day) for a month in Mac 2014 and the average was calculated.

- Determination of the average quantity of ablution water

  Ablution water was collected using the bucket method for a worshipper of an average of 10 people. This method involved filling a bucket and used a stopwatch to determine the length of time the ablution was performed. The volume of water for each person differs according to the activity. The measurement of water demand was determined using the bucket method. This method involved filling a bucket of known volume and used a stopwatch to determine the time taken to fill it up. The volume of the bucket divided by the time taken to fill up the bucket will yield the value of the flow.

- Determination of water consumption

  A water audit survey was done to determine the water consumption. A few activities were identified such as ablution, toilet flushing, irrigation, and reverse osmosis (RO) drinking water.

- Estimation of water savings

  The estimation of water savings was a projection achieved if the proposed ablution water was performed. The treated ablution water will be proposed to be reused for toilet flushing and water irrigation. The amount of water demand for irrigation and toilet flushing were estimated based on the water consumption activities. The water used was calculated and compared with the water bill obtained from the local water authority (SAJ). The total current water usage is then calculated using the SAJ link (http://www.saj.com.my/v2/calculatorbm.php).

## 3. Results and Discussion

The summary for the mean value of untreated and treated with sand + gravel filter at Parit Raja mosque and Pintas Puding mosque is presented in Table 1. In general, the mean concentrations of typical parameters of treated ablution water showed remarkable reduction of TSS, $NH_3$, COD, and BOD concentration.

Table 1. The summary for the mean value of untreated raw sample and treated ±StDev at two mosques in Parit Raja during the sampling period from 28 February to 14 March 2014

| Parameter | Units | Parit Raja mosque | | Pintas Puding mosque | |
|---|---|---|---|---|---|
| | | Mean ± Standard Deviation (Untreated) | Mean ± Standard Deviation(Treated) | Mean ± Standard Deviation (Untreated) | Mean ± Standard Deviation (Treated) |

| | | | | | |
|---|---|---|---|---|---|
| pH | - | 7.14 ± 0.28 | 7.73 ± 0.07 | 7.13 ± 0.27 | 7.07 ± 0.07 |
| DO | mg/L | 6.92 ± 0.54 | 6.81 ± 0.44 | 6.82 ± 0.64 | 6.12 ± 0.22 |
| TSS | mg/L | 9.0 ± 3.0 | 6.0 ± 1.73 | 10.67 ± 2.52 | 1.53 ± 1.53 |
| $NH_3$ | mg/L | 0.77 ± 0.06 | 0.60 ± 0.02 | 0.71 ± 0.09 | 0.05 ± 0.05 |
| COD | mg/L | 3.66 ± 0.32 | 3.12 ± 0.41 | 3.50 ± 0.12 | 0.15 ± 0.15 |
| $BOD_5$ | mg/L | 31.0 ± 1.73 | 27.67 ± 1.53 | 31.0 ± 4.36 | 24.16 ± 4.16 |

Based on the National Water Quality Standard (NWQS), the maximum threshold limit of TSS for Malaysian irrigation (Class IV) is 300 mg/L. The TSS values in this study were within the limit and the TSS value from Parit Raja mosque has improved from 9.0mg/L to 6.0mg/L after being filtered through sand and gravel. Furthermore, treated ablution water from Pintas Puding mosque showed the level of TSS concentration was reduced from 10.67mg/L to 1.53 mg/L. Normally, the suspended solid were made of inorganic materials, through bacteria and algae which were due to the gargling activity during ablution (Fondriest, 2015). Previous study conducted by Khatun (2011) and Mohamed & Ali (2012) had demonstrated that the TSS concentration in raw ablution water was low which ranged between 5-146mg/L and 19-49mg/L respectively. Therefore, the ablution water from Parit Raja and Pintas Puding mosque has low strength of TSS and it was saved to be reused for irrigation.

Biochemical oxygen demand (BOD) concentration was reduced tremendously in both mosques in which the value reduced was 31 mg/L to 27.67 mg/Land 31mg/L to 24.16 mg/L respectively. According to NWQS, the BOD concentration of ablution water exceeded the permissible limits recommended as categorized as class IV for irrigation. The BOD was considered high compared to NWQS recommended value (12mg/L). The BOD levels represent the amount of organic matter that may be released during the ablution of cleaning certain part of the body like rinsing the palm, mouth, and washing nose by sniffing. Usually, the BOD concentration is associated with dissolved oxygen and high BOD value shows a reduction in DO (Al-Badaii et al., 2013). A large amount of organic matter enhances the microorganisms to consume more DO to complete the biological processes. From previous study, ablution water generated from the mosques in Egypt was found to be low in strength because the BOD varied between 17 mg/L-23 mg/L. The water quality of ablution water varies in quantity in a wide range depends on the usage patterns as well as on the sources and locations (Khatun et al., 2011).

The chemical oxygen demand (COD) concentration of the ablution water samples were reduced after treated with sand and gravel filter which were 3.66 mg/L to 3.12mg/L at Parit Raja mosque and 3.50mg/L to 0.15 mg/L at Pintas Puding mosque. In addition, these results were within the standard allowable limit recommended by NWQS which is 100 mg/L or less and is classified as class IV. Comparing the COD concentration obtained from both mosques (Parit Raja and Pintas Puding) to a previous study by Pidou et al. (2007), the ablution water from Riyard City Mosque, Saudi Arabia showed high strength of COD which varied between 260mg/L to 280mg/L. Moreover, both mosques showed low level of COD when compared to Dhaka's mosque and Dhaka's residential area greywater in which the concentration were 51-60mg/L and 85-462mg/L respectively (Khatun et al., 2011). The value of COD may vary due to several reasons such as the number of the worshippers, the ablution steps, climate, and also the landform of the country. Generally, low COD level indicates a low level of pollution, whilst high level of COD points out high level of water pollution in the study area.

The ammonia ($NH_3$) concentration in the sample of ablution water from Parit Raja mosque was 0.77 mg/L before treated and 0.60 mg/L after being filtered. Meanwhile, the ammonia level at Pintas Puding mosque was reduced from 0.71mg/L to 0.05mg/L after treatment. According to the NWQS, the maximum threshold level of $NH_3$ for Malaysian water which is suitable for irrigation is 2.7mg/L. Nevertheless, the concentrations of $NH_3$ from both mosques were within this range and were classified as class IV. In addition, higher $NH_3$ value can be toxic to plants but in small concentration it could serve as the nutrients for excessive growth of algae (Al-Badaii et al., 2013).

*3.1 Water Savings Estimation*

Water is a limited resource in arid countries and water conservation becomes important (Rose et al., 1991). In Malaysia, the excessive use of water has affected the availability of the resource (Hamilton et al., 2007). One way of conserving water is by recycling the ablution water from mosque. Table 2 shows the quantity of ablution water per person in performing the wudhu and the method showed that one worshipper uses about 5 L of greywater in 48.5 seconds averagely. People seldom close the taps while performing wudhu' and half of the water flows directly into the drain without any contamination (Al-Mamun et al., 2014). Water wastage can be

avoided during ablution. It occurs when some worshippers left the water flow running without being fully utilized and take a relatively long time to perform ablutions. There are also some cases where some worshippers open the tap at maximum flow for ablutions.

Table 2. The quantity of ablution water per person during performing wudhu

| User | Quantity of Water (ℓ) | Time Taken (s) |
|---|---|---|
| 1 | 5.6 | 50 |
| 2 | 5.0 | 46 |
| 3 | 5.3 | 55 |
| 4 | 4.7 | 48 |
| 5 | 4.9 | 43 |
| 6 | 6.3 | 59 |
| 7 | 5.1 | 52 |
| 8 | 4.3 | 42 |
| 9 | 4.5 | 43 |
| 10 | 5.5 | 47 |
| **Total** | **51.2** | **485** |
| **Average ± Stdev** | **5.12 ± 0.59** | **48.5 ± 5.6** |

Figure 2 shows the frequency of worshippers for a month (March). The number of the worshippers visited Pintas Puding mosque was calculated. The number of worshippers during Friday prayer was recorded to be high. Therefore, it is estimated that the ablution water consumption produced at Pintas Puding mosque for a month is about 83.45 $m^3$.The high number of worshippers may also be affected by the location of Pintas Puding mosque in which it is located near residential colleges and industrial areas.

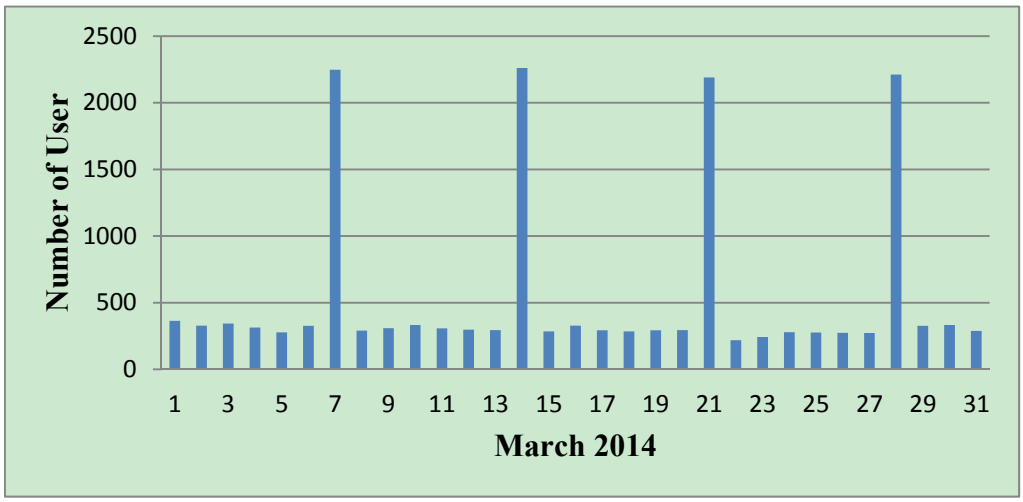


Figure 2. Frequency number of users for a month (data collected March 2014)

Figure 3 shows the percentage amount of water consumption in Pintas Puding mosque daily. There were five main water sources that contributed to the main water consumption in Pintas Puding mosque, namely ablution water, toilet pipe, 6 flushing toilets (without sinks), 4 bathrooms, 1 RO drinking water, 6 hand wash basins, and irrigation. Based on the pie chart, an ablution activity contributes the highest percentage of greywater with 92.56% of total water demand, due to the number of worshippers who come to perform their prayer at the mosque from nearby student hostels. Normally, the number of worshippers that come to the mosque consists of 50% hostel

students, workers, and residents. The layout of the Pintas Puding mosque and the main water sources is depicted in Figure 4.

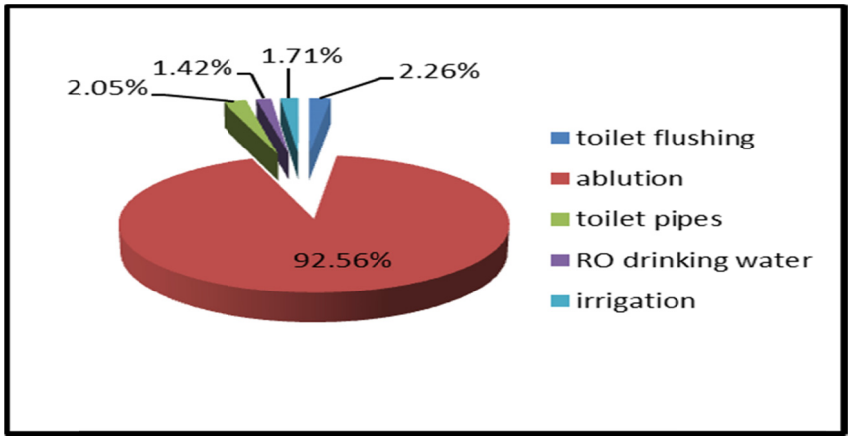


Figure 3. Water consumption of Pintas Puding mosque per day

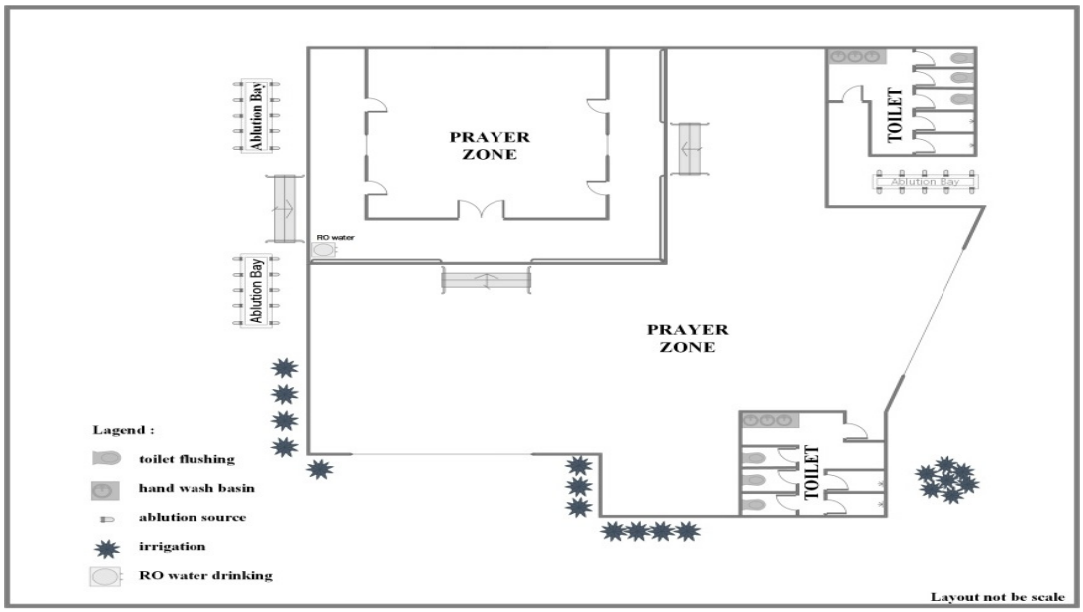


Figure 4. Layout plan of the Pintas Puding mosque

Figure 5 shows the estimation of water savings when the treatment system is installed at Pintas Puding mosque. It can be estimated that the total volume of water discharged from the ablution was 1625 L, toilet pipelines discharge was 36.69 L, and RO drinking water was 25 L. The total discharge was 1686.69 L. The installation of conventional (sand and gravel) filter in Pintas Puding mosque has potentially improved the effluent of ablution water for reuse purposes. The treated ablution water can be reused for toilet flushing and landscape irrigation in which the water required was only 36 L and 30 L respectively. Based on the calculation, 41.73% of water can be reduced from the total amount of water demand per month.

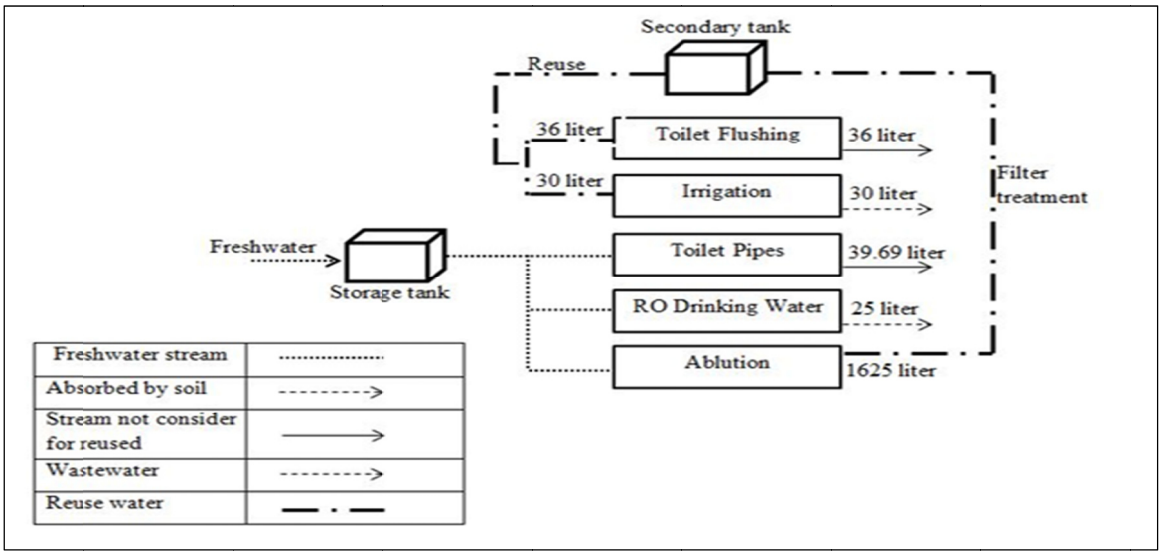


Figure 5. The flow diagram of water demand per day


Figure 6. The calculation of water usage by SAJ link

Usually, the water bill for treated water for each month is RM525.15. After the usage of the sand and gravel filtration was introduced, the water bill could be reduced to as much as RM180.16 for 83.45 $m^3$ of water consumed. Therefore, the reduction of water usage in the mosque remarkably could save about RM344.99 per month. The current water bill calculated by SAJ link is shown in Figure 6. The water consumption was reduced because three out of the five activities only used the treated water. Therefore, this model is significantly important to be widely proposed because the amount of water savings shown remarkable well and the method of installation is cheap and simple.

## 4. Conclusions

Applying conventional filter treatment (sand and gravel) showed that the reduction of pollutants in ablution water was achieved. The tested ablution water that was taken from the Parit Raja Mosque had reduced TSS

parameter of6.0 ± 1.73, $NH_3$ parameter of 0.60-0.02mg/L, COD parameter of 3.12-0.41mg/L and BOD parameter of 27.67-1.53mg/L. Meanwhile, for the Pintas Puding mosque, the TSS parameter was 1.53-1.53mg/L, $NH_3$ parameter was 0.05-0.05mg/L, COD parameter was 0.15-0.15mg/L, and BOD parameter was 24.16-4.16mg/L. The proposed treatment system was capable of reducing water consumption by 41.73% with monthly water bill saving of RM 180.16. The water savings can be further reduced up to 50.83% if the treated ablution water is reused for irrigation and toilet flushing. Hence, a huge amount of cost saving up to RM2161.92 can be achieved.

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