Full Paper of the WasteSafe 2025 – 9th International Conference on
Sustainable Solutions for Waste Management in Developing Countries
22-23 February 2025, Dhaka, Bangladesh

# REUSE OF ABLUTION WATER FROM MOSQUES IN THE PRODUCTION OF CEMENT MORTAR FOR USE IN CONSTRUCTION

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## ABSTRACT

*During five daily prayers, a considerable amount of ablution wastewater is produced in mosques. In a developing country like Bangladesh, where wastewater treatment systems are poorly established, greywater is directly discharged into the environment through open drains. This wastewater is often logged nearby, creating a breeding place for parasites. This study aims to find the feasibility of recycling the greywater to prepare mortar for construction. The essential characteristics of greywater were investigated in the laboratory, test specimens were prepared by replacement of normal mix water with untreated and treated ablution wastewater using Ordinary Portland Cement to compare their strength properties. Following ASTM test methods, specimens were tested to determine the effect of greywater on the strength properties of mortar. The results showed that using such wastewater doesn't significantly deteriorate the tested properties of mortar. Therefore, it can be a suitable alternative to freshwater in producing satisfactory-grade mortar, contributing to environmental sustainability and economic efficiency.*

**Keywords:** *Greywater, Recycling, Satisfactory-grade mortar, Environmental sustainability.*

## INTRODUCTION

Groundwater scarcity is one of the most significant global issues affecting the ecosystems worldwide. In addition to drinking, groundwater has traditionally been utilized for various household purposes, including cooking, cleaning, and personal hygiene. One of the key uses of groundwater is its use in the practice of ablution by Muslims for personal cleanliness and religious practices. However, in most cases, once the water is used for ablution, it is typically considered greywater and discharged to the local drainage system. Greywater is the wastewater generated from households, except the waste from the water closets (Oron et al., 2014); (Maimon et al., 2010). This practice raises concerns about water waste and improper wastewater management. As water resources become increasingly scarce, the demand for freshwater is continuously rising. To address these conflicting trends, greywater reuse is gaining popularity as a viable solution worldwide for water conservation to promote sustainable practices. Implementing on-site greywater treatment, reuse, and recycling is crucial in addressing water scarcity, especially in arid and semi-arid regions (Shaikh & Ahammed, 2020). This practice involves treating and reusing greywater for non-potable purposes such as irrigation, industrial cleaning, toilet flushing, etc. Nevertheless, it is necessary to understand its primary contaminants in order to use greywater for potable purposes and find the most efficient treatment process.

Firstly, the characteristics of greywater from a household vary widely depending upon the number and age of occupants, people's living habits, customs, living standards, and use of household detergents, chemicals, and body care products (Spychala et al., 2019). However, greywater is considerably less polluted than domestic wastewater due to the absence of urine, feces, and toilet paper in it, and contains only about 30% of the total organic load and 10–20% of the nutrients present in domestic wastewater (Beck et al., 2013); (Pidou et al., 2007). Various technologically advanced treatment methodologies, for example, activated sludge process, up-flow anaerobic sludge blanket, membrane bioreactor, trickling filter, rotating biological contractor, and oxidation ditch, are widely studied, well documented, and adopted in practice.

However, attention to promising low investment-cost technologies, such as slow sand filtration (SSF) techniques, is surprisingly minuscule. SSF (at a flow rate of 0.1–0.2 m3 /h) is quite effective water treatment technology.(Verma et al., 2017)

Greywater recycling offers several advantages. Reusing treated GW not only preserves scarce water sources but also reduces water supply costs and decreases the load on centralized wastewater treatment systems (Beck et al., 2013) which minimizes the negative impacts and costs of water extraction and wastewater treatment (Santos et al., 2014), so recycling greywater can ensure more sustainable use of water. It is reported that about 25–30% of potable water consumption can be reduced by reuse of GW (Vuppaladadiyam et al., 2018). In many water-scarce areas of the world, governmental legislation has made GW recycling mandatory for newly constructed buildings. A recent study comparing a wastewater centralized reuse system and a GW decentralized reuse system showed that the GW system consumed only between 11.8% and 37.5% of the energy of a centralized system considering the same number of inhabitants served (Matos et al., 2014).

Furthermore, the quality of mixing water can affect various properties of cement mortar. Alkaline mixing waters (up to pH13) positively affect the compressive strength and workability of the cement mortars. (Çomak, 2018) Mixing water with high sulfate ions reduces the compressive strength development of cement mortar (Onesmus Mulwa et al., 2016).

In this paper, we will see how greywater and cheaply treated greywater affect the compressive strength of Portland cement mortar in the filter. Addressing groundwater scarcity through greywater management can significantly promote sustainable water practices and protect valuable freshwater resources for future generations.

## MATERIALS AND METHODOLOGY

Materials used in the research:

I. Ordinary Portland cement (BDS EN 197-1:2003, CEM I/ 52.5NASTM C-150, Type – I, Clinker: 95-100%, Gypsum : 0-5%).
II. Medium Coarse sand (FM= 2.74).
III. Ablution water(Collected from KUET central mosque).
IV. Drinking water(Collected from Amar Ekushey Hall, KUET).

A slow sand filter was made using a plastic container, porous clothes, fine sand, coarse sand, and gravel. Half of the greywater collected from the mosque was filtered through this slow sand filter. The drinking water was collected from the supply provided in Amar Ekushey Hall, KUET.

The water quality of the drinking quality water, filtered greywater, and unfiltered greywater were determined. Then the mortar was mixed and cas using the drinking quality water, the unfiltered greywater, and the filtered greywater into 2-inch cubes. The cement-to-sand ratio used in the mortar mix is 1:3.For each type of water,3 cubes were cast. The cubes were then cured for 7 days. After that, compressive strength tests were conducted on these specimens. The test data were collected. The compressive strength of the mortar was determined by averaging the compressive strength of the 3 samples. Then the strength of the drinking quality water mortar, unfiltered greywater mortar, and filtered greywater mortar were compared.

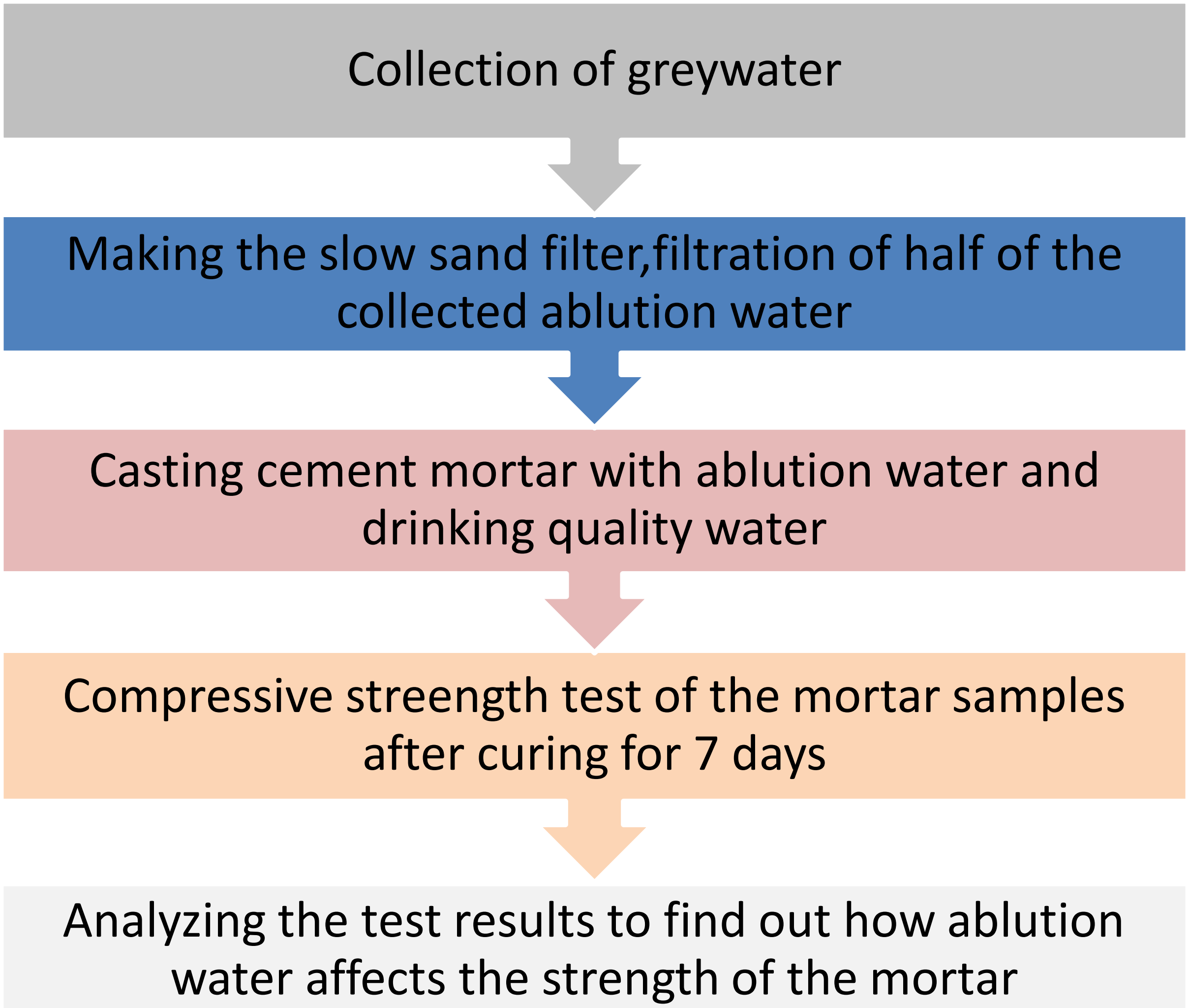


Figure 1 Simplified methodology of the work

**Filtration**

Half of the collected greywater was filtered using a slow sand filter. Different greywater recycling schemes reported to date achieve very different performance levels. Simple technologies and sand filters have been shown to have only a limited effect on greywater, whereas membranes have been reported to provide good solids removal but cannot efficiently tackle the organic fraction (Pidou et al., 2007). A very cheap slow sand filter was made using a plastic container, porous clothes, fine sand, coarse sand, and gravel. Small holes were made at the bottom of the container to let the filtered water get out of the container. The ratio of the fine sand and coarse sand gravel was 3:1:1. The total length of the filter was 20 inches. Therefore, the height of fine sand, coarse sand, and gravel were 12 inches,4 inches, and 4 inches respectively. The filtration of the greywater took only around 6-7 minutes because the amount of water was not very large.

*ISBN: 978-984-35-7297-4*

Figure 2 The slow sand filter

**Testing of water quality parameters**

**P$^H$ :**

Apparatus: EZDO P$^H$ meter.

The sample was taken into a beaker and the electrode of the PH meter was inserted into the sample to determine the P$^H$.

Figure 3 P$^H$ Test

**Iron and Manganese:**

Apparatus: HACH DR3900 Laboratory Spectrophotometer for water analysis.

Reagents: Ferrozine (for iron concentration test), Manganese Reagent-I and II (for Manganese concentration test).

For the testing of iron concentration, a 10 ml sample was taken.4-5 drops of ferrozine were added to the sample and left for 5 minutes. Then it was inserted into the HACH DR3900 and the reading was taken. For the testing of manganese concentration, a 10 ml sample was taken. Then 0.2 gm of Manganese Reagent-I was added and the mixture was left for 5 minutes after that 0.1 gm of Manganese Reagent-II was added and the mixture was left for 2 minutes. Then the sample was inserted into the HACH DR3900 and the reading was taken.


Figure 4 Iron and Manganese conc. Test

**Total Dissolved Solids(TDS):**
Apparatus: TDS meter.
The sample was taken into a beaker and the electrode of the TDS meter was inserted into the sample to determine the TDS.


Figure 5 Total Dissolved Solids Test.

**Sulfate:**
Apparatus: HACH DR3900 Laboratory Spectrophotometer for water analysis.
Reagent: Sulfate Reagent.
10 samples were taken. Then 0.2 gm Sulfate Reagent was added and kept for 5 minutes. Then it was inserted into the HACH DR3900 and the reading was taken.

*ISBN: 978-984-35-7297-4*

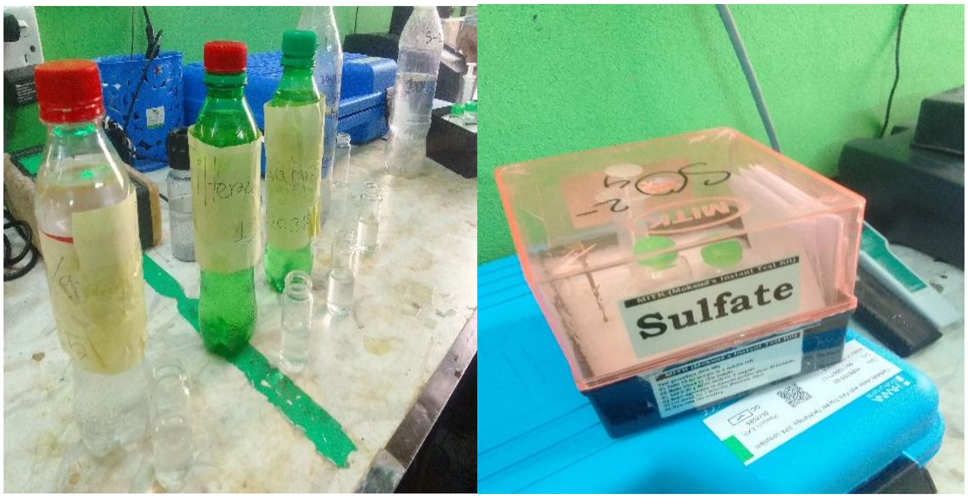


Figure 6 Sulfate conc. Test.

**Chloride:**
Titration is the process of adding measured amounts of a standard solution that reacts with the unknown to ascertain the quantity of the unknown chemical in the solution. The stoichiometry of the reaction and the quantity of standard solution required to reach the so-called endpoint can then be used to determine the concentration of the unknown. Reactions that produce ionic compounds with restricted solubility are the basis for precipitation titrations. Silver nitrate is the most significant precipitating reagent. Silver nitrate-based titration techniques are sometimes referred to as argentometric techniques. By interacting with silver ions to produce a brick-red silver chromate precipitate in the equivalency point region, potassium chromate can be used as an end-point indicator for the argentometric detection of chloride, bromide, and cyanide ions. Chromate ions are used as an indication in the Mohr method, which titrates chloride ions using a standard solution of silver nitrate. The endpoint is indicated by the production of a silver chromate precipitate from the initial excess of titrant, which occurs after all of the chloride has precipitated as white silver chloride. The amount of chloride in an unknown sample can be ascertained by knowing the stoichiometry and moles consumed at the endpoint. Experiments to ascertain the amount of chloride present in a solid sample are described in this process.
Equipment and Reagents:
The reagents used in this experiment were K2CrO4 and AgNO3.
The equipment used is listed below:
Buret, pipette, volumetric flask, wash bottle.

$$\text{Chlorides mg/L} = \frac{(V_S - V_B) * \text{Normality} * 35.45 * 1000}{\text{Volume of sample taken}}$$

Figure 7 Testing of chloride concentration.

Figure 8 HACH DR3900 Laboratory Spectrophotometer for water analysis.

**Compressive strength of mortar**

The compressive test of mortar was done according to ASTM C109 / C109M – Standard Test Method for Compressive Strength of Hydraulic Cement Mortars. The mortar was cured for 7 days. So, the compressive strength we determined is the 7-day compressive test of mortar. Portland cement, coarse sand(Sylhet sand), and the sample waters were used to make the mortar. The mold was assembled and oiled before preparing the mortar. Firstly, the pre-calculated amounts of cement, coarse sand, and water were taken using a balance and beaker.

Then the cement, and coarse sand were mixed thoroughly and water was added to it. The mixture was then mixed properly for about 2 minutes. The mortar was then cast immediately into the molds in 2 layers, each layer was tamped 32 times. Then the mortar was left to settle for 24 hours. Then the cubes were taken out from the molds and were submerged in water for 7 days to cure. All the samples were cured in the same water. Then after 7 days, the strength of the cubes was tested in the compressive strength testing machine in SSD condition.

*ISBN: 978-984-35-7297-4*


Figure 9 Casting and compressive strength testing of mortar.

**Survey of KUET mosque**

A survey of the KUET central mosque was done for 7 days and the average number of Muslims who use clean water before the prayer was determined for each of the 5 times of prayer. At Fazr, around 60-70 people, at Johr,asar, and Magrib around 200 people, and Esha around 120 people gather for prayer. So, the average headcount per day is around 750(approximately) in total. They consume about 6.4 liters of water at every period of prayer which has been obtained by experimental analysis of 100 worshippers.(Nur Uddin et al., n.d.).

So, the total water consumed every day and turned into greywater is around 4800 liters. If we recycle the ablution water for a week the total amount becomes 33600 litres. For casting every cubic meter of mortar having a w/c ratio of 1:3, around 240 liters of water is needed. Therefore around 140 cubic metres of mortar can be cast using ablution water from a single mosque in a week.

## RESULTS AND DISCUSSION

### Water quality parameters

Table 1 Test results of water quality parameters.

| Type of Water | Tested Parameter | Result |
|---|---|---|
| Greywater (Collected from KUET Mosque) | $P^H$ | 7.5 |
| | TDS | 542 mg/L |
| | Iron | 0.037 mg/L |
| | Manganese | 0.4 mg/L |
| | Sulfate | 13 mg/L |
| | Chloride | 319.9 mg/L |
| Filtered Greywater | $P^H$ | 7.4 |
| | TDS | 482 mg/L |
| | Iron | 0.016 mg/L |
| | Manganese | Nil |
| | Sulfate | 13 mg/L |
| | Chloride | 272.415 |
| Drinking Water | $P^H$ | 7.4 |
| | TDS | 331 mg/L |
| | Iron | 0.046 mg/L |
| | Manganese | Nil |
| | Sulfate | Nil |
| | Chloride | 169.94 mg/L |

### Compressive strength of mortar:

Table 2 Test results of compressive strength of mortar.

| CastUsing | Load (KN) Sample No. | | | Avg. Load (KN) | Compressive strength (Mpa) =Avg. Load/A |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | | |
| Greywater | 11.73 | 11.64 | 11.32 | 11.56 | 4.48 |
| Filtered Greywater | 12.16 | 12.21 | 12.17 | 12.33 | 4.72 |
| Drinking water | 12.31 | 12.41 | 12.27 | 12.71 | 4.78 |

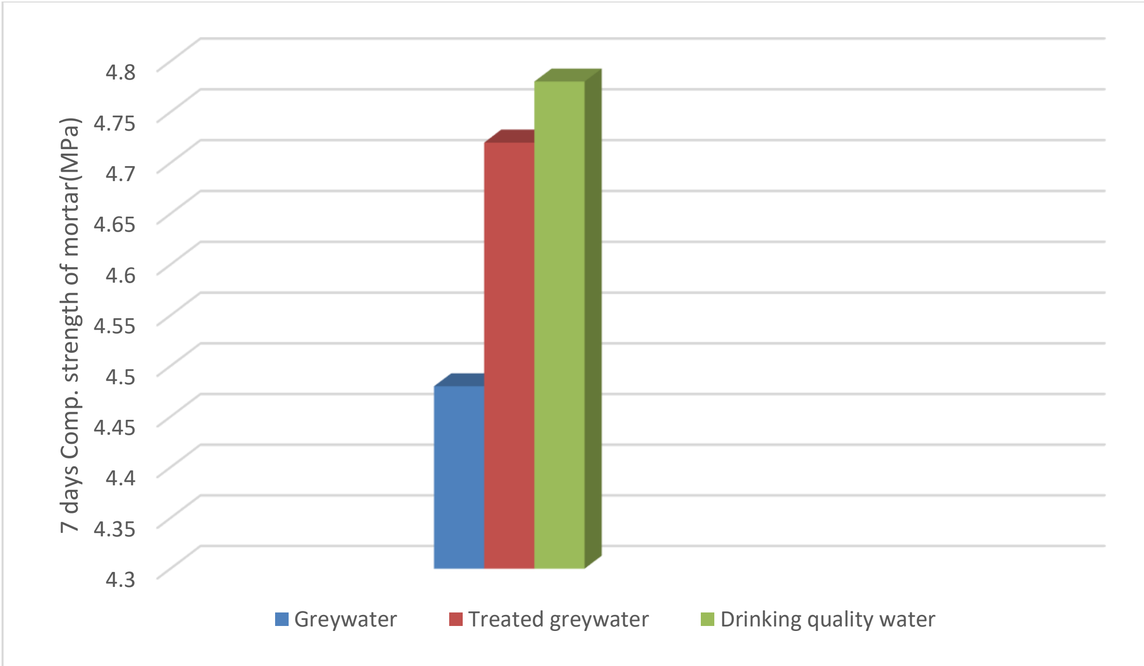


Figure 10 Comparison of compressive strength of mortar samples cast using different types of water.

The mortar cast using greywater, filtered greywater, and drinking water have a compressive strength of 4.48 MPa,4.72 MPa, and 4.78 MPa respectively.

The difference in strength between the mortar cast using greywater is 6.276% less than that of the mortar cast using drinking quality water. The mortar cast using filtered greywater had a compressive strength of 38.04 MPa which is 1.255% less than that of the mortar cast using drinking-quality water.

## CONCLUSION

From this research, we can see that ablution water from mosques can be a good alternative to drinking quality water in mortar mixing. Which suggests it might be a great alternative in concrete mixing as well. The results show that the strength reduction due to the use of greywater in mortar casting is not that large, only around 6% and we can also see that using a cheap slow sand filter can produce mortar of almost identical quality, with only around 1% reduction in strength.

In Bangladesh, a huge amount of ablution water is released into the drains every day. This water mixes with dirty, contaminated water, then goes into rivers or has to be treated as sewerage water to be usable. But the ablution water and greywater from mosques and households don't need to be treated as sewage water and can be used in construction, cleaning, etc. This will reduce the money and energy wasted in treating this water as sewage. From the result, we can also see that using a cheap filter, can be the replacement of drinking quality water in construction works and provide almost identical results. Which also requires way less amount of money and energy than the treatment process. Recycling ablution water also reduces waste of clean surface water and thus it will contribute to environmental sustainability.

From the survey on the KUET mosque, we saw that around 140 cubic meters of mortar can be cast from 1 week of ablution water from a single mosque. Which is a considerable amount. Dhaka City, the capital of Bangladesh, has over 6000 mosques. There are thousands of mosques in other cities too. If we can reuse the ablution water from these mosques in construction works, a huge amount of water will be saved every day. Which will also reduce the cost and energy used in the freshwater supply system.

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