# USE OF BRICKS AS AN ALTERNATIVE FILTER MEDIA FOR PEBBLE MATRIX FILTERS (PMF)

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## ABSTRACT

Filtration of drinking water by Slow Sand Filters (SSFs) is a well known water treatment technique in tropical countries. The efficiency of Slow Sand Filters (SSF) decreases during heavy rain periods resulting from high turbidities. As a novel pretreatment method, the Pebble Matrix Filters (PMF) technology has been used to treat high turbidity water. During the construction of first full scale PMF plant in Sri Lanka at Kataragama, problems were encountered in sourcing of required uniform size and shape of pebbles due to high cost, scarcity and government regulations on pebble dredging. To investigate possibilities of utilizing alternative filter media for PMF, laboratory tests were conducted using different configurations with chips and burnt bricks due to its availability in Sri Lanka. Results showed that bricks as an effective and feasible alternative filter media to natural pebbles. It can be observed that turbidity removal efficiency has increased with the increment of influent turbidity when the bricks used as the filter media compare to chips. Head loss development also has very similar value of pebble matrix filters. In the tested filtration velocity of 0.16 m/h and inlet turbidity range of (60-600) NTU produced above 80% removal efficiencies.

***Keywords*: PMF, sand filters, turbidity, bricks**

## 1. INTRODUCTION

A novel pretreatment method called PMF developed at University College London proved that it can be used as a pretreatment method before passing high turbidity water to SSF in tropical monsoon conditions [1]. However, sustainability of PMF technology depends on availability and supply of pebbles and sand. During the construction of first full scale PMF plant in Sri Lanka at Kataragama, number of problems was encountered in sourcing the required size of pebbles and sand as filter media. This is mainly due to the difficulties in obtaining suitable pebbles. Hence, the use of an alternative media for PMF has been investigated for the sustainability of the PMF system. According to the literature, it was found that the use of clay balls and recycled crushed glass as alternative media to natural pebbles was not a viable option due to number of reasons [2]. For example, producing clay balls requires a kiln with high temperature. This incurs an additional cost for preparing particular sizes of clay balls having sufficient compressive strength [3]. Hence, this paper presents the results of investigations carried out of the evaluation of cost effective and sustainable alternative filter media to PMF which is suitable for tropical countries.

## 2. METHODOLOGY

Figure 1 shows the schematic diagram of the filter model which was constructed using wood and fiber. The height, length and width of the model are 90 cm, 60 cm and 30 cm respectively. The lower compartment which is 18 cm height is used to collect filtered water. Overflowed water above the weir at the influent is collected to the existing compartment located next to the weir of the model. Circular pipes of one inch diameter with taps were fixed at end of pipes on either sides of the bottom of the lower compartment, one of the pipes is for the effluent of the filtered water and the other one is for the overflowed effluent. An iron mesh wrapped up with linen net clothe was placed at the bottom of the upper compartment. This is to pass the filtered water easily into the lower compartment. The head loss through the filter bed was measured using two 5 mm diameter glass tubes fixed at depths of 20 cm and 72 cm from the top of the model as shown in Fig. 1.

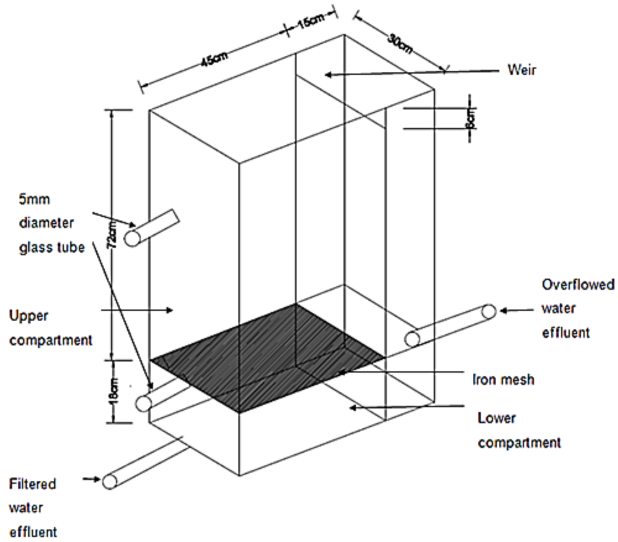


**Figure 1: Schematic Diagram of the Filter Model**

In this research burnt bricks and chips were tested as alternative filter media. Chips, bricks and sand were collected from construction sites. They were cleaned well and a sieve analysis was carried out as per BS 1377-Part 2 to obtain the particle size distribution and mean diameter. However sieve analysis was not carried out for bricks due to practical difficulties and diameter range was determined using manual observations. River sand was used to mix with brick and chips to prepare the required media-sand mixture of the filter bed.

Two media were tested using the laboratory scaled filter column with three discrete layers. The configuration of the filter is first layer, made of 60mm chips of 2-10mm diameter, second layer with a 300 mm layer of sand and filter media mixed in the ratio of 1:1, and the third layer with a 10mm layer of the selected filter media. The ratio of 1:1 was chosen for the second layer due to the reason of giving highest turbidity removal [4].

The influent turbidity was kept at 60 NTU value in all experimental series while operating for 4.5 hours and effluent turbidity was measured in every fifteen minutes intervals. Filter model was operated at filtration rate of 0.16 m/h. Initially two configurations were tested as follows;

Configuration 1 - 60mm layer of chips of 2-10 mm diameter as the bottom layer, 300 mm mix bed with chips: sand volume ratio 1:1 and 10 mm layer of chips of 5.14 mm in mean diameter as the top layer.

Configuration 2 - 60mm layer of chips of 2-10mm diameter as the bottom layer, 300 mm mix bed with bricks: sand volume ratio 1:1 and 10 mm bricks of 50mm in mean diameter as the top layer.

The configuration that gave the highest turbidity removal efficiency was selected as the optimum configuration and it was tested for different influent turbidity values as 200 NTU, 300 NTU, 400 NTU and 500 NTU in order to observe the response of the selected configuration for higher influent turbidity values.

## 3. RESULTS AND DISCUSSION

Table 1 shows the test results for each configuration for medium 1 and medium 2 when influent turbidity was 60 NTU. It can be seen that removal efficiencies of 75.17% and 79.33% were achieved for the two configurations. The configuration 2 was selected as the optimum configuration where turbidity removal efficiency is higher [4].

**Table1: Test results for Configuration 1 and Configuration 2 for Influent Turbidity of 60 NTU**

| Configuration | Media | Mean Diameter (mm) | Media: Sand Volume Ratio | Head Loss (cm) | Min. Effluent Turbidity (NTU) | Efficiency (%) |
|---|---|---|---|---|---|---|
| 1 | Chips | 5.14 | 1 : 1 | 6.1 | 14.9 | 75.17 |
| 2 | Bricks | 50.00 | 1 : 1 | 6.0 | 12.4 | 79.33 |

Table 2 shows the variation of turbidity removal efficiency for different influent turbidity values for optimium configuration. When the influent turbidity is 60 NTU the minimum turbidity removal efficiency was about 79%. However when the influent turbidity is 600 NTU it was about 94%. It clearly shows that turbidity removal efficiency has increased with the increase of influent turbidity.

**Table 2: The Variation of Minimum Effluent Turbidity and Turbidity Removal Efficiency with Influent Turbidity**

| Influent Turbidity (NTU) | Minimum Average Effluent Turbidity (NTU) | Turbidity Removal Efficiency (%) |
|---|---|---|
| 60 | 12.4 | 79.34 |
| 200 | 22.5 | 88.75 |
| 300 | 28.1 | 90.64 |
| 400 | 31.7 | 92.08 |
| 600 | 31.6 | 94.74 |

This phenomenon can be explained as, the roughing of filters which allow deep penetration of suspended materials in to a filter bed and they have large silt storage capacity. When raw water flows through a packed bed of coarse media, a combination of filtration and gravity settling takes place which invariably reduces the concentration of suspended solids. Moreover, sinuous flow of water through the interstices of coarse media provides repeated contacts among the small suspended particles to form compact settleable flocs. A portion of the agglomerated floc settle on the surface and within the interstices of coarse media, which further helps in adsorbing finer particles as they come into contact with the settled flocs. In an up-flow system as the flow emerges from the coarse media, due to sudden drop of velocity, agglomerated flocs settle on the top of coarse media bed forming a layer of sludge blanket which is also effective in the removal of finer particles. (5)

Hence, when the influent turbidity becomes high, the amount of silt or sludge storage blanket on top of the filter media layer is also high. It will help to increment of turbidity removal efficiency furthermore.

## 4. CONCLUSIONS

This study shows that broken bricks with sand in 1:1 ratio have greater potential for turbidity removal as a pretreatment media. Furthermore, bricks can be utilized as a feasible alternative to natural pebbles currently used in pebble matrix filters. Bricks perform as well as or better than the pebbles in the removal.

## 5. REFERENCES

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