



THE DESIGN OF FILTERS WITH LOW COST MATERIALS FOR SMALL COMMUNITIES

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1. Introduction

Filters are used for the final clarification of liquids, often to a very high degree of removal. In practice there are two principal types of filters namely (i) slow filters and (ii) rapid filters, depending on their flow rates. The removal mechanism in slow filters is physio-chemical and biological. The major disadvantage of slow filters is that they require very large areas compared to rapid filters. Anyhow it is not a problem as far as water supply for small communities is concerned, particularly in Asian countries.

The principal objectives of this study are:

- 1) to see the possibilities of utilizing sand as conventional sand medium and locally available other media such as coconut fiber and burnt rice husk and 2) to study the performance of horizontal pre-filters followed by a conventional slow sand filter.

2. PERFORMANCE OF SLOW FILTERS WITH LOCALLY AVAILABLE MEDIA

Slow sand filters using local materials as filter media are considered to be an attractive alternative for producing potable water in rural communities in Asia. The availability of land, labour, local materials, no chemical required and climatological conditions in Asia favour the use of slow sand filters which would be an inexpensive method of treating surface water.

The selection of the media should satisfy the following criteria.

1. The first consideration in choosing filter media should be based on (a) longer filter run and (b) reasonable quality.
2. Availability and abundance: One of the prime considerations in the selection of filter media should be the availability and abundance. The selection of locally available media would considerably reduce the transport cost and most efficient utility of local resources.
3. Applicability for the raw water condition: To suit the applicability the raw water condition should be considered. The one that is selected for the low turbidity conditions may not be suitable for the highly turbid conditions.

4. Ease of preparation: In the preparation of media the following physical parameters have to be considered; (a) effective size; (b) shape; and (c) uniformity coefficient.

The physical parameters like density, durability, structural strength should also be considered along with the storage ability, and the cost of the media in the selection of filter media.

The following materials which are abundantly found in Asia can be successfully used as filter media, (Jaksirinont, 1972):

- (a) pea gravel-~~pebble~~;
- (b) charcoal;
- (c) raw rice husk;
- (d) burnt rice husk;
- (e) shredded coconut husk;
- (f) sand.

Different above mentioned materials were tried and following procedures and combinations were found to be the best (Sevilla, 1971 - Jaksirinont, 1972 - Thanh et al, 1976).

Suitable Combinations

- (i) Series slow filtration system:

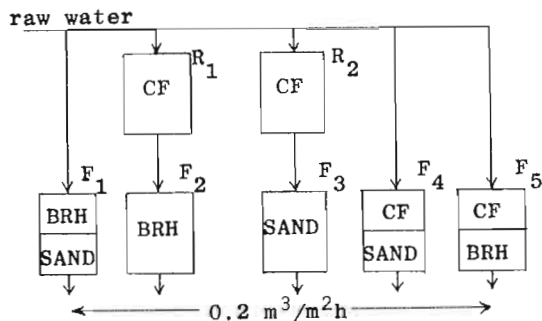
In this system coconut fiber filter was used as roughing filter followed by sand or burnt rice husk filter as polishing filter.

- (ii) Dual media slow filtration system:

In this system coconut fibre-burnt rice husk and coconut fibre-sand combinations were used.

The pilot model used for the study is as shown in Figure 1. Table 1 summarizes a few of the results obtained. From the vast number of results obtained (Thanh et al 1976) the following conclusions can be made.

- (i) Coconut fibres proved to be a reliable medium in prefilters for removal of gross impurities from highly turbid surface waters. At lower filtration rate of 0.5 m/h, head loss development through the filter bed was slow and longer filtration run can be achieved. Another characteristic of coconut fibres as a prefilter tolerate turbidity fluctuations in the raw water.
- (ii) Although filtrate quality was constant and superior in the case of sand filter as polishing filter, the burnt rice husk demonstrated a net superiority over sand as a polishing filter in terms of length of filter run.



CF = coconut fibre, BRH = burnt rice husk

FLOW DIAGRAM OF SERIES-FILTRATION AND DUAL-FILTRATION

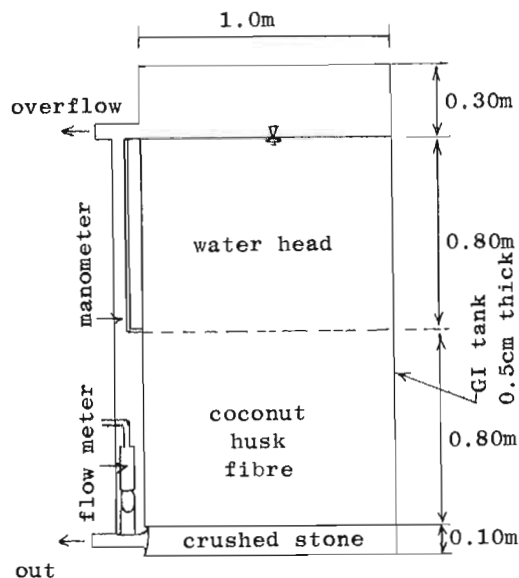


Fig.1 - ROUGHING FILTER (TYPICAL)
SCALE 1:50

- (iii) Although the dual-media filter consisting of coconut fibre and sand produced a good quality, in respect of village water supply, it was not suitable due to short filter run requiring frequent filter cleaning. The dual-media filters consisting of burnt rice husk and sand, burnt rice husk and coconut fibres produced a good quality water with a slow rate of headloss development. These filters could be used for a duration of a few months without cleaning. However, the disadvantage of this dual-media arrangement resides in the production of an unpleasant odour resulting from the prevailing anaerobic conditions forcing premature shutdown of the unit. The odour problem arises after a continuous use of three months.

- (iv) With regard to the microbiological aspects of water quality, all the treated waters still contained relatively high numbers of total coliforms, rendering them unsuitable for village domestic consumption if bacteriological International Drinking Water Standards are rigidly applied. However, the removals of faecal coliforms and Faecalis were quite substantial.

3. PERFORMANCE OF HORIZONTAL PREFILTERS FOLLOWED BY A CONVENTIONAL SLOW SAND FILTER

The horizontal flow prefiltration technique using coarse gravel or crushed stones as filter media is also a sound alternative in handling turbid waters. The main advantage of horizontal flow filtration is that when raw water flows through it a combination of filtration and gravity settling takes place which invariably reduces the concentration of suspended solids. The effluent from the prefilter, being less turbid, can be further easily treated by the conventional slow sand filter.

Figure 2 shows the layout of the water treatment plant at Jedeethong village in Thailand which uses the horizontal prefilter facilities. This plant is constructed for the population of 1000. The design details are presented elsewhere (Thanh, 1978). A few of the results obtained during operation is summarized in Table 1.

From the past three year's operation, following conclusions can be made:

- a) The removal efficiency of the prefilter was around 50 per cent. The filtrate quality was consistent after the "ripening Period" (about 20 days after the starting of operation). The overall efficiency of the system was of the order of 92 per cent.
- b) The horizontal prefilter accounts for 80 per cent removal of coliform organisms while the total system accomplished 96-99.99%. Once the ripening period was attained (about three weeks after the starting operation), highest removal of coliforms was observed, ensuring safe treated water for drinking purposes.
- c) DO content was found to be higher in the prefilter effluent than that of the raw water.
- d) The average head loss development rate 0.6 cm/day leads to the conclusion that filter runs of five months could be achieved in the case of horizontal filter if extrapolation of headloss is permitted.

4. GENERAL CONCLUSIONS

1. The dual media filter consisting of coconut fibre and burnt rice husk demonstrated its potential for treatment of tropical surface waters for village community water supply.
2. With proper maintenance and careful supervision, longer filter runs can be achieved by the implementation of slow sand filtration coupled with horizontal prefiltration.

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TABLE 1

System	Filtration velocity ($^3/m^2 h$)	Turbidity (JTU)		Total Coliform MPN/100 ml		Headloss	
		Influent (average)	Effluent (average)	Influent (average)	Effluent (average)	Headloss Rate cm/day	Filter Run (day)
1. Series Filtration System							
(i) Coconut Fiber + Burnt Rice Husk	0.5	100	20	1500	25	0.5	more than 3 months
(ii) Coconut Fiber + Sand	0.5	100	20	1500	25	0.5	more than 3 months
	0.2		3		15	2.4	60
	0.2		10		12	2.4	33
			(Effluent quality improved gradually)				
2. Dual Media System							
(i) Coconut Fiber + Burnt Rice Husk	0.2	100	5	1500	20	1.3	90
(ii) Coconut Fiber + Sand	0.2	100	2	1500	15	3	41
(iii) Burnt Rice Husk + Sand	0.2	100	3	1500	30	0.5	more than 3 months
3. Horizontal Prefilter + Slow Sand Filter	—	25	12	5000	1000	0.6	more than 5 months operation
			3		100	0.5	

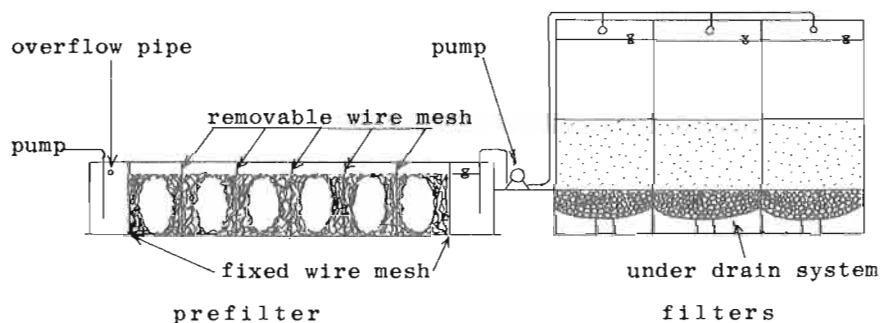


Fig.2 - Section A-A of Horizontal Prefilter and Slow Sand Filters
Scale 1:50