



A novel water filter technology for rural areas

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Abstract

Most of rural community in India does not have access to safe drinking water. The purpose of this work is to provide a technology for obtaining safe drinking water for rural population by a low cost, easy to make, domestic water filter system. The filter is made of rice husk ash (RHA) which is available in abundant quantity in rural India. The performance of the RHA based water filter is good with the bacterial trapping of $96\pm 3\%$ and turbidity removal of $94\pm 3\%$. A field study of filter has been carried out at KEM Rural Hospital Vadu, which shows similar performance as in laboratory. Our studies also showed RHA based water filter is better than ceramic candle filter. We are working with several NGO's and UNICEF, India to proliferate this water filter. We have trained 40 NGO's with this innovative technology. More than 3000 filters made by village volunteers are presently in use.

Introduction

According to the recent WHO (World Health Organisation) assessment (Mathys, 2000), there are at least 5 million deaths/year due to the use of unsafe drinking water and at least 1.4 billion do not have access to drinking water. About one third of these deaths take place in India alone. Therefore providing safe drinking water to villages is of paramount importance in developing countries. To address such a gigantic problem, novel technical, managerial and financial solutions are required. The work reported in the present paper is one such attempt.

The thrust in this E&D effort is on the use of the commonly available rice husk ash (RHA) as a filtration medium. It was first tried by Frankel, 1979; however, the use of RHA for designing a usable filter element for domestic filtration in rural homes was new. TRDDC, Pune has done extensive research in this area and has filed two Indian Patents for this application (Sundaram et al., 1997), (Meher and Prasad, 1999). The patents describe the materials, the composition, and the processing details for the fabrication of the filter element and the container designs. RHA, pebbles and a binder such as cement are used for the fabrication of the filter. The filter is called as RHA-pebble matrix filter (RHA-PM filter). The performance of RHA-PM filter in terms

of improved water qualities for different types of influent water are tested and described in this paper. The paper also outlines studies carried out on this filter in the field. This can be easily fabricated in the village setting both for domestic and community use. For domestic use, the filter can be assembled in a plastic bucket which can be reused even after the expiry of the filter element's life by refilling. For community purpose also, a tank of any design and capacity can be fabricated for the filtration purpose. The best trapping efficiency for bacteria and turbidity are found to be 99% under certain laboratory conditions. However, there was considerable variation of this value from filter to filter when produced in larger numbers and it is one of the challenges of the project to understand and control the variation so that a realistic tolerance can be given for the trapping efficiency of bacteria and turbidity. The filtered water, though not strictly of WHO standard for bacteria, is expected to be useful in rural India considering the immunity level of the villagers. This is because the general bacterial level of drinking water in a typical village taken on a sample basis varies in the range of 1000 to 10000 CFU/100 ml and the water from the above type of filters has a bacterial level of 100 to 200 CFU/100 ml.

Materials and Methods

Materials

Rice Husk Ash (RHA): Three varieties of RHAs were used to make the filters depending on their source like Boiler ash, Brick Kiln ash and TiB ash (Kapur, 1985).

Pebbles or aggregates: Pebbles or aggregates can be obtained from river side or construction material supplier. Pebbles are used to provide a matrix for the filter bed, which make the bed robust.

Cement: Ordinary Portland Cement (OPC) is used to provide strength to the matrix and filter bed.

Plastic container: The filter bed is cast in perforated food grade plastic container. The cast bed is then covered with the perforated steel plastic plate which is then sealed with cement-and mixture.

Test Methods

Turbidity: The turbidity values of the samples were measured using Monitek Nephelometer (model 21) and are expressed in Nephelometer Turbidity Units (NTU).

Microbiological quality: The membrane filtration technique was utilised to determine the bacteriological quality of water. This gives qualitative estimate of the bacteria present in the sample, since the coliform (*E. Coli*) group of bacteria are the principal indicator organisms present in water, this is measured in Colony Forming Units per 100 ml of sample (CFU/100 ml).

Filter Fabrication Process

A filter making process is described in Figure 1. The process of making the filter element involves thorough mixing of RHA, pebbles and cement in required proportion along with water to the consistency of a concrete mix. The mix is rammed into a plastic container with holes at the bottom (placed on a tray to have a hard surface for ramming). After ramming, the top end of the bed is also covered with the plastic plate. The setting characteristics of the cement impart the necessary strength of the element. The output characteristics measured for this filter are bacterial trapping, turbidity, pH and filtration rate.

Results and Discussion

Standardisation of filter making process The filter fabrication process is simple but has to be perfectly done to get good trapping efficiency. The cause of variations is mainly due to fabrication and maintenance. We have standardised the filter fabrication process after considering each aspect so as to make the process more simple and robust.

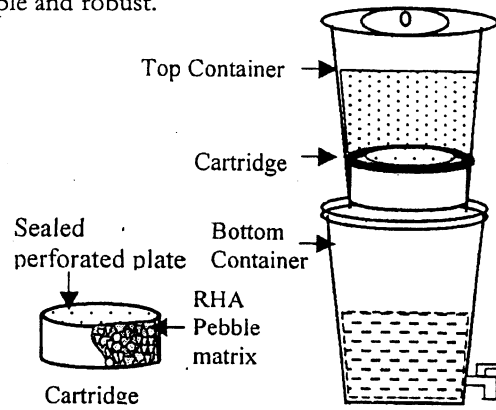


Fig 2. : Schematic of fabricated water filter.

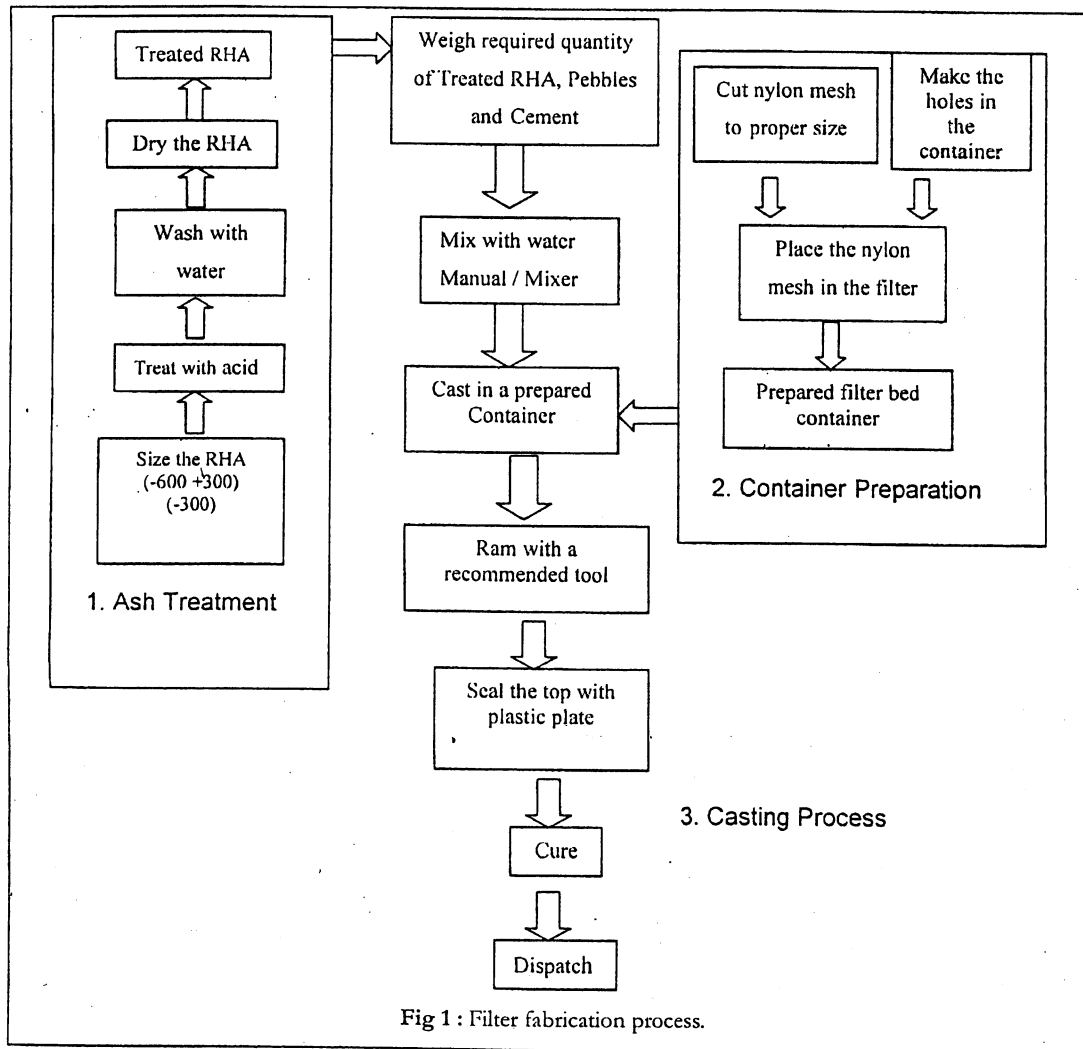
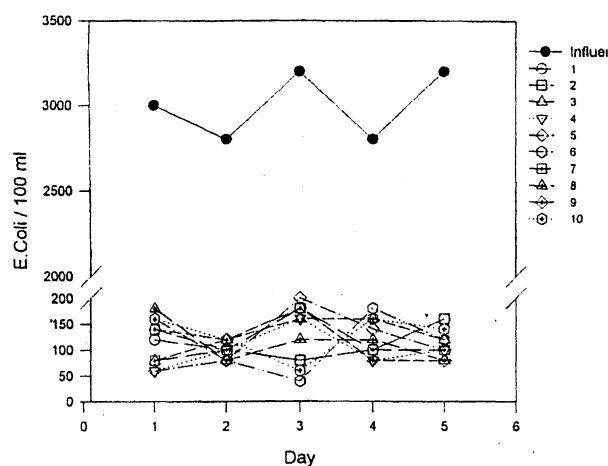


Fig 1 : Filter fabrication process.

The filters (Figure 2) can be made in batches of 10 filters and can be easily fabricated with the local tools available in the rural areas. The filters made were tested in our laboratory for bacterial count and turbidity of filtered water so as to check the filter to filter variations in a batch. The bacterial count was found in the range of 150 ± 50 CFU/100ml (Figure 3) and turbidity in the range of 0.3 ± 0.1 (Figure 4). This showed that filter fabrication process is robust and standard.



Note : Number in legend represents filter # 1 to 10.

Fig 3. : Performance of filters in a batch of 10 for bacterial trapping.

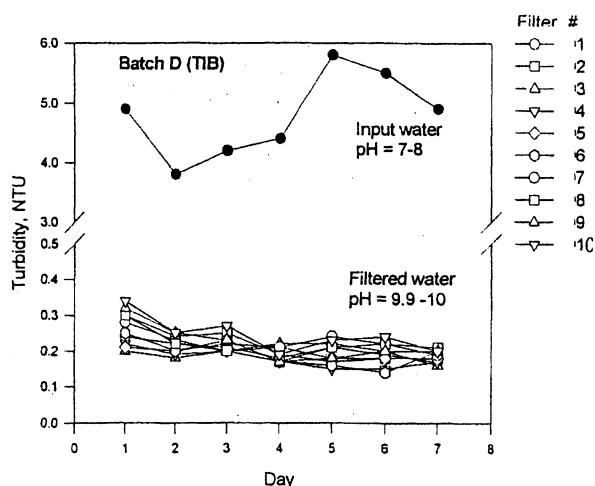


Fig 4 : Performance of filters in a batch for turbidity removal.

Typical input and output water quality tested in laboratory

The RHA filter was thoroughly tested for water from different sources with widely varying levels of contamination for pH, turbidity and bacterial count (Table 1). The bacterial counts for the canal water is

20000-30000 CFU/100 ml, which came down to 500-700 CFU/100ml by filtration. Similarly the bacterial count for well water was in the order of 2000-3000 CFU/100ml which came down to 80-100 CFU/100ml. The canal water turbidity is 10-25 NTU which after filtration came down to 0.3-0.7 NTU.

Table 1—Typical input and output water quality of water filter

Parameters	Canal water		Well water	
	Input	Output	Input	Output
Bacterial count CFU/100ml	20000 30000	500- 700	2000- 3000	100-300
Turbidity NTU	10-25	0.5±0.3	3-7	0.4±0.2
pH	7-8	8.5±0.2	7-8	8.5±0.2

Comparison with candle filter

The performance of the RHA pebble matrix filter was compared with the commercially available ceramic candle filter. Both the filters were tested over a period of 5 months. The tests involved extent of removal of suspended particle, bacterial trapping and clogging rate. The filters were tested for highly turbid input water (around 50 NTU). The performance of the filter was characterised on the basis of laboratory tests and is given in Table 2. It was found that the cost of the RHA filter element is 1/3rd of the cost of ceramic candle with 10% and 25% more efficiency in bacterial trapping and turbidity removal respectively. Also the filtration rate of RHA filter is found to be two times of ceramic candle filter.

Table 2 — Comparison of RHA-filter with Candle-filter tested for 3000 litres of water

Parameters	RHA filter	Candle filter
Cost of filter element	30/-	100/-
Bacterial count CFU/100ml	100-200	150-300
Turbidity NTU	0.4±0.1	0.6±0.1
Filtration Rate	2.4±0.1	1.5±0.1

Field Trails and case study

Field trails on water filter was carried out at KEM Rural Hospital Vadu village for a year to study its performance. The samples were collected on regular basis every months up to 5 months. The beds were replaced after six months. The bacterial counts for KEM hospital filter was in the range of 100-200, while Doctors' Mess filter had 120-300 CFU/100ml with the input water in the range of 1800-3000 CFU/100ml. The turbidity level for KEM hospital and Doctors' Mess filter was in the range of 0.3-0.5 and 0.2 to 0.4 NTU respectively, with the input water turbidity of 3-5 NTU (Table 3).

Table 3 —Performance of filters at KEM hospital

Parameters	Doctors' Mess filter				KEM Hospital filter				Influent (Borewell)			
	8/8	9/9	12/9	4/12	8/8	9/9	12/9	4/12	8/8	9/9	12/9	4/12
Date (2000)	8/8	9/9	12/9	4/12	8/8	9/9	12/9	4/12	8/8	9/9	12/9	4/12
Bacterial count CFU/100ml	120	180	200	340	120	200	140	200	2800	2800	3000	1800
% bacterial trapping	96	94	93	84	96	94	95	89				
Turbidity level (NTU)	0.35	0.3	0.4	0.44	0.25	0.22	0.28	0.32	4.5	4.8	3.7	2.6
% turbidity trapping	92	94	89	83	95	96	93	89				
PH	8.7	8.5	8.5	8.2	8.8	8.6	8.6	8.4	7.8	7.5	7.8	7.3

Achievements

KEM hospital Pune has certified filtered water through filter suitable for drinking. We have given training for fabrication of filter to about 40 NGOs through several training workshops.

Presently about 3000 filters made by village volunteers are being used in villages.

A case study was carried out at Pusane village for over a year, it indicated substantial reduction in diseases.

Summary and Conclusions

The filter fabrication process is robust and the filters can be easily fabricated at rural level with the help of simple tools.

The filter has a unique design, it is created from ready-made materials available in the rural market.

Performance of filter in the field was found to be good.

The bacterial trapping of filter is around $96 \pm 3\%$ and turbidity trapping is $93 \pm 3\%$.

The filtration rate is between 1.8 to 3 litres/hr.

The RHA pebble filter is found to be better than ceramic candle filter.

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