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Appropriate technology for water filtration

Dr (Mrs) T R Mampitiyarachchi

Introduction

Effective methods of water treatment are of great importance to both developing and developed countries. Developing countries have to seek for treatment processes that are less expensive to construct and operate. Also the process involved has to be simple as the skilled manpower available is limited.

Filtration of water through granular media is widely used either for removal of solid material from water or for removal of flocs and the solid material after coagulation,flocculation and sedimentation processes. Although various types of filters are available,slow sand and rapid sand filters are used very widely. The usage of former is restricted to the rural areas while the latter is extensively used in the urban areas. Both types of filters use sand as the filter medium, but the rapid sand filters require uniformly graded sand. Generally slow sand filters are operated at or around 10 $m^3/m^2/d$. However rapid sand filters can be operated at rates equal to or greater than 120 $m^3/m^2/d$.Slow sand filters require cleaning after long intervals of time (upto 60 days or more) where as rapid sand filters are back washed at least every 24 hours.

Filter media other than sand have been used in practice, with varying degrees of success, examples are anthracite coal and plastics. The diatomaceous earth filter aid, is used in precoat filtration. A thin film of this fine filter material is sufficient for this purpose. The applications of this type of filters are limited due to high cost of the filter medium.

Rice hull ash - as an alternative filter medium

Rice is one of the major food crops of the world and is widely consumed in Asia. The majority of paddy cultivating areas lie within the developing countries. Milling of paddy yeilds a by product,rice hull,which amounts to about 20% of the weight of the paddy. Hulls have peculier properties such as abrasiveness due to high silica content, low nutritional value and a slow rate of decomposition. Although there are several potential uses for rice hulls at present the majority of hulls is disposed on land, causing land pollution. Rice Hull contains about 21% silica. The combustion of hull yeilds an ash which can contain as much as 90% silica. Ash retains the original texture of the hull particles and hence gives a porous structure. Thus it can be used as a filter medium. Utilization of rice hull ash as a filter medium requires the evaluation and comparison of its performance in relation to removal of turbidity and bacteria with that of a conventional filter medium.

Properties of rice hull ash

Rice hull on combustion yields a porous ash with a density in the range of 1900 to 2200 kg/m^3. The carbon content of this ash was found to vary between 3 to 6% and silica content between 85 to 87% with 4% moisture.

Ash particles are of fibrous nature and the average length and width are found to be 2.12 mm and 0.74 mm, respectively. Mechanical seiving of ash particles indicate that the effective size and non uniformity coefficient are 0.135 mm and 2.96, respectively. X-ray diffraction analysis shows that the silica in the ash exists in amorphous form.

Model filters

Laboratory filter columns 2.25 m high, 144 mm internal diameter were constructed of clear perspex tubing. Each filter column was fed using a lateral pipe located 150 mm from the top and a constant water level was maintained by having an overflow pipe, 50 mm below the top. Ten pressure tappings were located at the lower half of the column and provision was made to measure the head loss through the column by connecting them to water manometers. Outflow from each column was from the base and the flow control was done at the outlet section using a needle valve and a precalibrated rotameter.

Turbid water for experimental filter runs was made by adding kaolin clay to tapwater and the water was stored in a 1000 litre capacity galvonized iron tank. 4 grammes of kaolin clay dispersed in 100 litres of tapwater produced a turbidity of 40 FTU. Turbidity measurements were made on a Spekkar Absorptionmeter (Hilger & watts Ltd., England) which was calibrated using formazin standards. Turbid water was pumped into a 200 litres overhead tank which in turn fed filter columns.

Bacterial suspensions were made by adding a pure culture of 'Escherichia Coli' into dechlorinated tap water. The bacterial counts of inflow and outflow water was measured using the plate counting technique.

Details of Filter media

Filter sand used in comparison studies had an effective size of 0.64 mm and a non uniformity coefficient of 1.41. The density of sand was 2640 kg/m^3. The depth of the filter medium was 750 mm. Both media (i.e sand and rice hull ash) were mounted on 200 mm deep layers of graded gravel. The initial porosity of the sand medium was 44% and that of rice hull ash was 93.5%.

Semi rapid filtration rates between 0.25 m^3/m^2 h and 2.0 m^3/m^2 h were adopted. In general, a head loss of 1m was used as the criterion for termination of any particular filter run.

Performances of alternative filter media

Table 1 summarizes and compares the performance of rice hull ash and sand filter media operated at semi rapid filtration rates in relation to the removal of turbidity from water. Both sand and rice hull ash filters at a given filtration rate were operated simultaneously.

A typical comparison of performance is given in Fig. 1. In general filtrate (outflow) turbidity of rice hull ash filters was equal or less than that of a sand filter operated at the same rate. Filtration efficiency, based on ratio of influent turbidity to filtrate turbidity appears to increase with time for rice hull ash filters.

Based on a head loss of 1m and the maximum amount of water produced, a filtration rate 1m^3/m^2 h appears to be the optimum rate of filtration for rice hull ash filters.

Filtration of water that contained Esherichia-Coli at selected filtration rates through sand and rice hull ash filters indicated that a certain amount of bacterial removal can be expected in both filters. However at the rates adopted, it was not possible to achieve 100% reduction to avoid disinfection of the water. Typical results obtained are shown in Figs. 2 & 3.

Series filtration

Rice hull ash filters when operated in series and can be used to attain better reductions of turbidity. Typical results are shown in Fig. 4. In this filter run, the primary filter which reduced a major proportion of turbidity was operated at 0.5 m^3/m^2 h, while the secondary filter was operated at 0.5 m^3/m^2 h. The resulting turbidity of filtrate of the combined system was less than or equal to 2 FTU for an influent turbidity range of 30-60 FTU. The primary filter was cleaned twice, while secondary filter did not require any cleaning for a period of 60 days.

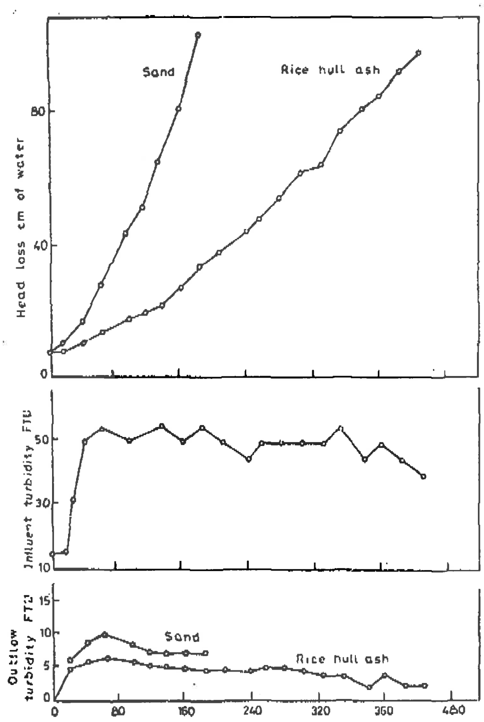

Fig. 1 Performances of sand and rice hull ash media at 1 m^3/m^2 h
Depth of medium = 750 mm

Table 1 Comparison of Filter Performance

Rate of filtration m^3/m^2 h	Type of medium	Turbidity Range F.T.U.		Rate of head loss, mm/d
		Influent	Filtrate	
0.25	Rice hull ash	30 - 60	1.0 - 3.0	very low
0.25	Sand	30 - 60	1.0 - 5.0	75.0
0.5	Rice hull ash	35 - 55	1.5 - 5.7	29.0
0.5	Sand	35 - 55	3.0 - 5.0	154.0
0.75	Rice hull ash	30 - 60	1.5 -11.0	59.5
0.75	Sand	30 - 60	1.3 -18.0	240.0
1.0	Rice hull ash	40 - 60	2.5 - 7.0	52.0
1.0	Sand	40 - 60	5.0 -11.0	129.0
2.0	Rice hull ash	20 - 25	5.0 - 7.0	212.0
2.0	Sand	20 - 25	7.0 -10.0	387.0

Cleaning of rice hull ash filter medium

Due to the fibrous nature of the particles it was not possible to clean the rice hull ash medium by fluidization techniques. Hence a cleaning procedure similar to that of a slow sand filter was adopted. This involved scraping of the upper layers of the medium and refilling to a proper depth using fresh rice hull ash.

Prediction of filter performance

Two techniques namely that suggested by Ives (ref.1) and that suggested by Hswing and Cleasby (ref. 2) were used to arrive at a suitable method to predict the performance of rice hull ash filters at semi rapid filtration rates. The statistical model based on

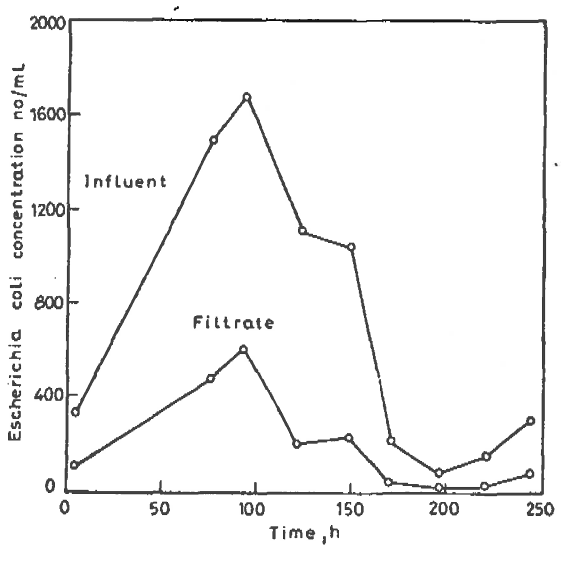

Fig. 2 Bacterial removal by sand medium
rate of filtration = 1.0 m^3/m^2 h
depth = 750 mm; porosity = 44%

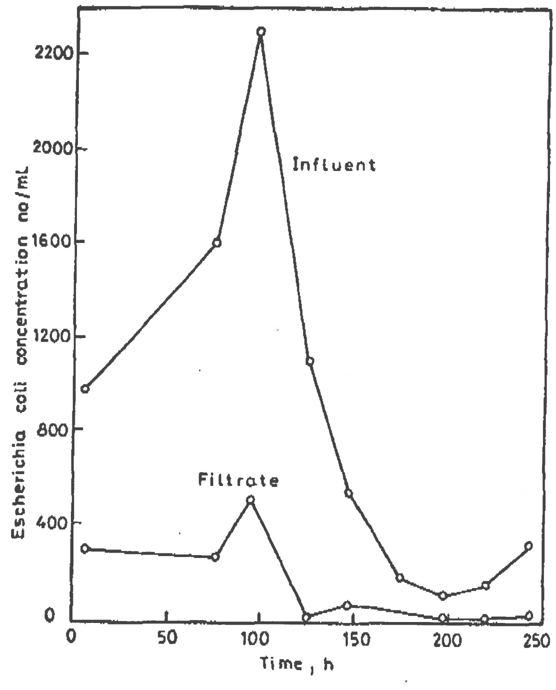

Fig. 3 Bacterial removal by rice hull ash medium
depth = 750mm ; porosity = 93.5%
rate of filtration = 1.0 m^3/m^2 h

Table 2 Prediction of Filter Performance
Medium - Rice hull ash
Depth - 685 mm,
Rate of filtration=0.5 m^3/m^2 h

Time h	Filtrate suspended solids concentration/ influent suspended solid concentration	
	Observed	Predicted
75	0.038	0.048
100	0.040	0.035
150	0.036	0.039
200	0.036	0.045

chi - square distribution analogy (ref.2) appears to be more suitable for the purpose. This method requires data from at least three thin layer filters, operated under similar conditions, to predict the performance at the same rate at any depth of the filter medium. It was necessary to express the turbidity of influent and filtrate in terms of suspended solids concentration. In the analysis of the data a time interval of 25h was taken as one degree of freedom. Typical comparison of predicted and observed values are give in Table 2.

Conclusions

Rice hull is readily available in rural areas of developing countries of the world. Combustion of hull yeilds porous ash which is rich in silica and can be used as a filter medium. When used as a granular medium, it effectively removes turbidity from water at semi-rapid filtration rates. The performance is better than that of a sand filter operated under the same conditions. The high porosity and the fibrous nature of ash particles, lower the head loss through the medium, and hence, a longer operating period is ensured for a given head loss.

A filtration rate of 1m^3/m^2 h appears to be the optimum rate for this medium. Series filtration appears to be an attractive solution to treat high turbid water as well as moderately turbid water. However disinfection after the process is required.

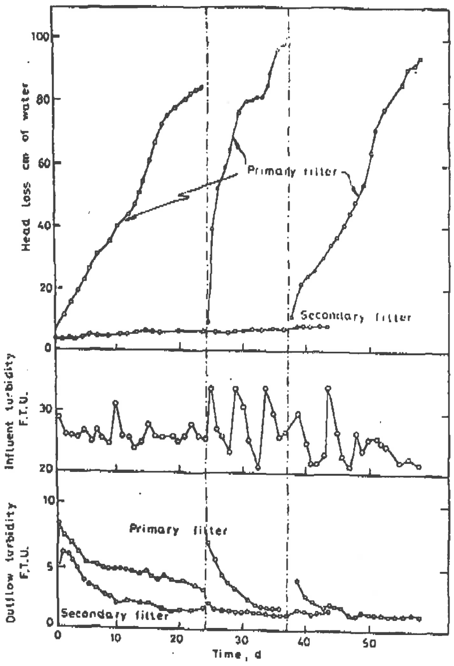

Fig. 4 Series filtration using rice hull ash medium.

rate of filtration of the primary filter = 1.0m^3/m^2 h

rate of filtration of the secondary filter = 0.5m^3/m^2 h

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1. IVES K J. Rational Design of Filters, Journal of Institution of Civil Engineers, Vol 16,1960,189 - 193

2. HSUING K and CLEASBY J L. Prediction of filter performances, Journal of Sanitary Engineering Division, Proceedings of American Society of Civil Engineers, Vol 94, 1968,1043 - 1067.