POTENTIAL OF BURNT OIL PALM SHELL (BOPS) GRANULES IN DEEP BED FILTRATION

AHMAD JUSOH*
M.J.M. MOHD NOOR*
A. HALIM GHAZALI*

SUMMARY: A study on the influence of effective size of Burnt Oil Palm Shell (BOPS) granular media in a rapid filtration process with respect to turbidity, filter run and flow rate was carried out at Sungai Langat Water Treatment Plant, Selangor, Malaysia. The finding of the study showed that effective sizes of less than 2.0 mm could produce effluent turbidity of less than 1 NTU, a limit recommended by WHO. Furthermore, it was noted that the filter run increased with higher effective sizes. Filter run was also affected by a change in the flow rate whereby a 50% increase in the flow rate resulted in the reduction of filter run by half, for the effective sizes studied.

Key Words: Burnt oil palm shell granules, deep bed filtration.

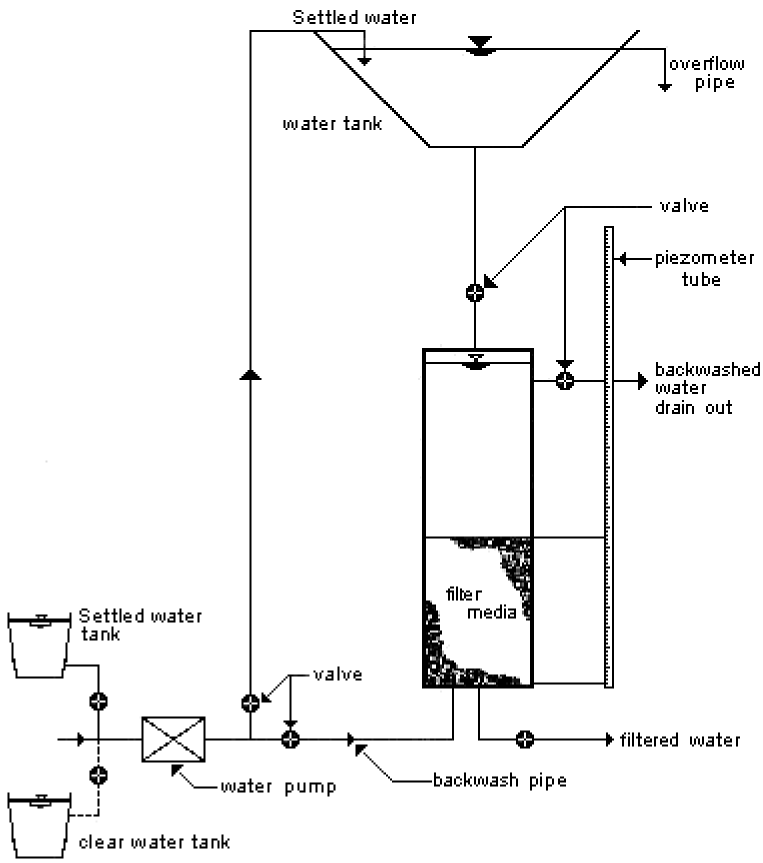
INTRODUCTION

The main function of rapid filters in water treatment is to clarify the water by removing suspended impurities. The principal mode of actions are generally physical and physico-chemical, with very minimal biological action. The major processes can be summarized as straining, flocculation and sedimentation. Typical impurities commonly found in water include bacteria, algae, viruses, iron and manganese oxides, radioactive particles, chemicals added in the pre-treatment, heavy metals and many other substances.

*From Department of Civil and Environmental Engineering University Pertanian Malaysia 43400 UPM, Serdang, Selangor, Malaysia.

Filter efficiency is dependent upon the characteristics of the liquid, suspended matters and the filter media. Some of the properties of filter bed which affect filtration efficiency are; size and shape of grain, porosity of the bed, arrangement of grains whether from fine to coarse of vice versa and the depth of bed. In general, filter efficiency increases with smaller grain size, lower porosity and greater bed depth. Hydraulic loading also effects filter efficiency whereby higher efficiency is attained at lower loading rate. According to Adin and Rebhun (1987), as velocity increases, the attachment coefficient of suspended solids decreases and the detachment gets larger, hence poor effluent quality.

Figure 1: Layout of a continuous filtration system.



Typical media used in water filtration are; coal, silica, sand and anthracite, either used singly or in combination (Kawamura, 1991). Filter media should be strong and robust, durable, spherical shape and free from clay, loam and organic materials. Spherical or semi-spherical medium provides better filtration efficiency and their tortuous path allows particles to reside within the pores between particles.

Application of Burnt Oil Palm Shell (BOPS) granular material in deep bed filtration is rather new. Thus, the appropriateness of the filter medium and the efficiency of the process must be established. The study undertaken aimed at obtaining the effects of effective size of BOPS granules in deep bed filtration with respect to turbidity, filter run flow rate and head loss.

MATERIALS AND METHODS

BOPS granules was prepared by burning oil palm shells in a furnace at about 300°C without oxygen. The carbon material formed was then ground into granules and sieved to establish the particles size distribution curve. Finally it was graded into various effective sizes and uniformity coefficient as required. The distribution curved was reported in Ahmad *et. al.* (3). The porosity and specific gravitiy of BOPS medium determined were 0.52 and 1.4 respectively.

The filter column utilized in the study was fabricated from clear perspex and equipped with a backwashing facility as shown in Figure 1. The column was designed to operate as a gravity flow process with regulation valves to compensate for the increasing head loss and thus maintaining a constant rate of flow. The study was conducted at Sungai Langat Water Treatment Works, Selangor, Malaysia utilizing settled water prior to the rapid sand filtration.

Initially, BOPS of various effective sizes, Es, (1.0, 2.0 and 2.5 mm) and uniformity coefficient, U, of 1.5 were studied to obtain the optimum depth of filtration for each effective size. Common values of the uniformity coefficient for single-medium filters range between 1.3 and 1.7 (Tebbutt, 1988). The optimum depth was defined as the depth of the BOPS filter bed at which the effluent turbidity began to stabilize i.e., when no significant reduction in turbidity values occurred. The various effective sizes were obtained from the particle size distribution curve.

The filter column was operated at a flow rate of 10.0 $m^3/m^2/hr$ until effluent turbidity became stabilized which normally occurred after 30 minutes of filter run. The respective optimum depths of filtration for the various effective sizes were then utilized in the second stage of the study. Turbidity was only parameter being measured at this stage.

The second stage involved operating the filter at the optimum depths for the respective effective sizes mentioned until the head loss in the filter had reached about 2.5 m. The filter column was operated at the flow rates of 10.0 are 15.0 $m^3/m^2/hr$. Filter performance was monitored by observing head loss, filter run and influent and effluent turbidites at regular intervals. Backwashing was done prior to the subsequent operations.

RESULTS AND DISCUSSION

The first stage of the study was to obtain the optimum depth of BOPS media. Figure 2 shows the relationships of effluent turbidity and depth of medium for various effective sizes to indicate their respective optimum depth. The results showed that for all effective sizes, effluent turbidity reduced gradually and later remained constant as it approached the optimum depth. The smaller the effective size the lower was the effluent turbidity achieved. It can be seen that the optimum depth reduces with reduction in effective sizes as shown by the constructed line of optimum depth in the Figure 2. For instance, the effective depth for effective sizes of 1.0, 2.0 and 2.5 mm 60, 80 and 90 cm respectively. The determination of the effective depth was very important because utilizing unnecessarily thick bed would lead to undesired fast development of negative pressure in the filter media.

In order to determine the performance of the BOPS filter main parameters (head loss, flow rate and turbidity) were monitored. Average settled water turbidities

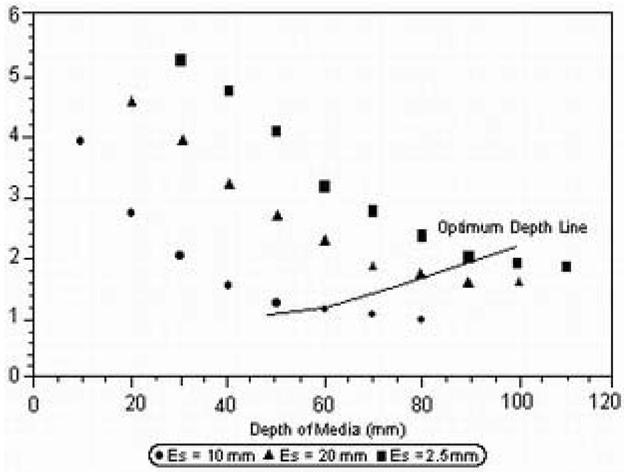


Figure 2: Relationship between effluent turbidity and depth of media for various effective sizes.

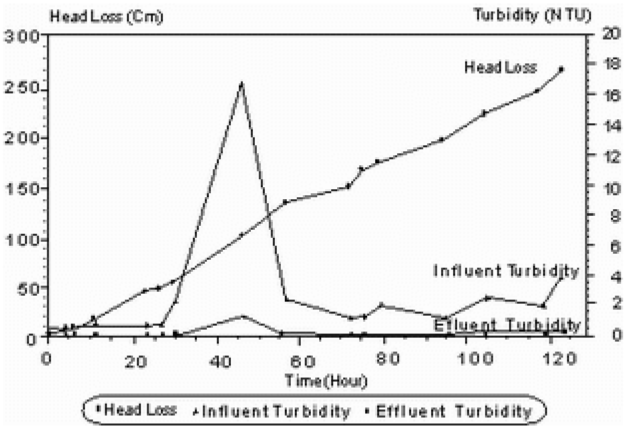
(influent) and effluent water turbidities and percentage of reduction in turbidity at flow rates 10 $m^3/m^2/hr$ and 15 $m^3/m^2/hr$ are shown in Table 1. From the results, it shows that with smaller effective size and lower flow rate the percentage of turbidity reduction is higher. This means that greater quantity of suspended solids will be trapped in smaller size medium and also, lower flow rate creates greater opportunity for the particles to settle, with respect to time, in the filter bed.

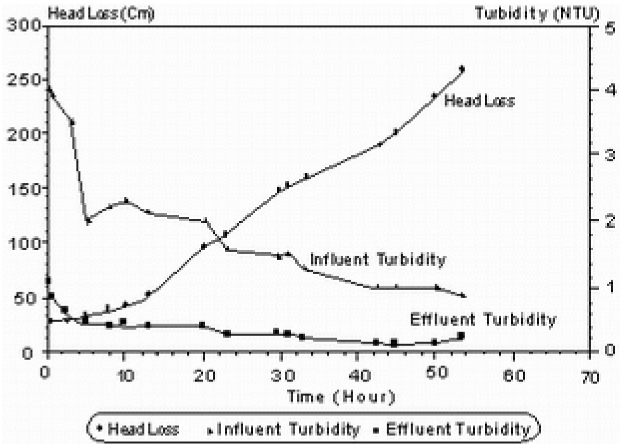
Table 1: Influent and effluent turbidities, and percentage of reduction at various effective sizes and flow rates.

Effective Size (mm)	Flow rate ($m^3/m^2/hr$)	Influent Turbidity	Effluent Turbidity	% Reduction
1.00	10 15	2.56 1.39	0.27 0.39	89.50 80.40
2.00	10 15	2.08 2.70	0.46 0.71	77.90 73.70
2.50	10 15	2.71 1.85	0.81 0.68	70.10 63.20

Figures 3 to 5 show the variation of turbidities and head losses with respect to filter run at flow rates, 10 and 15 $m^3/m^2/hr$, and effective sizes 1.0, 2.0 and 2.5 mm respectively. During normal conditions, the settled water turbidity or influent turbidity may vary between 2 and 5 NTU, however, under poor conditions (eg. after a

Figures 3a and 3b: Variation of turbidities and head losses for BOPS filter.



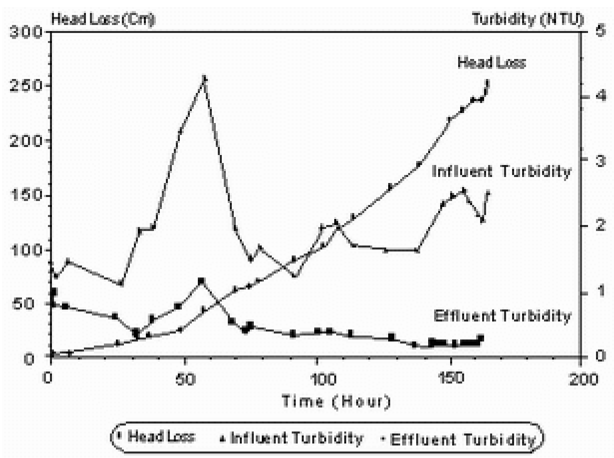


heavy rain) the turbidity of the settled water could increase to as high as 18 NTU. From Figures 3 and 4, under the normal condition, the effective sizes of less than 2.0 mm could produce the effluent turbidity of less than 1 NTU. This is the recommended limit set by WHO for drinking water (6). However, with effective size of 2.5 mm, the effluent turbidity was more than 1 NTU. The filter run increases with the increase in effective size. For instance, the filter run at the flow rate of 10 $m^3/m^2/hr$ and effective sizes of 1.0, 2.0 and 2.5 mm were 123, 165 and 230 hours respectively. The higher effective size medium can retain greater quantity of suspended solids, therefore allowing fewer backwashings and subsequently reducing the operation cost due to longer filter run.

For all effective sizes, increase in the head loss was gradual at the earlier stages of filtration and rapidly towards the end of the filter run. Breakthrough still did not occur as shown by the unchanged of the effluent quality, even though the head losses achieved a maximum value of 2.5 m. This indicates that the BOPS filter medium can serve as good as sand in term of quality even at a higher effective size of 2.5 mm. According to Tobiason and Vigneswaran (5), head loss development is typically linear with filter run time.

BOPS has several advantages over sand; in that

Figure 4a and 4b: Variation of turbidities and head losses for BOPS filter.



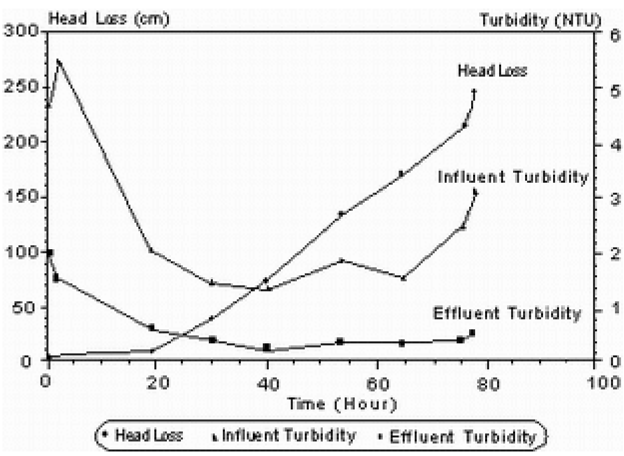
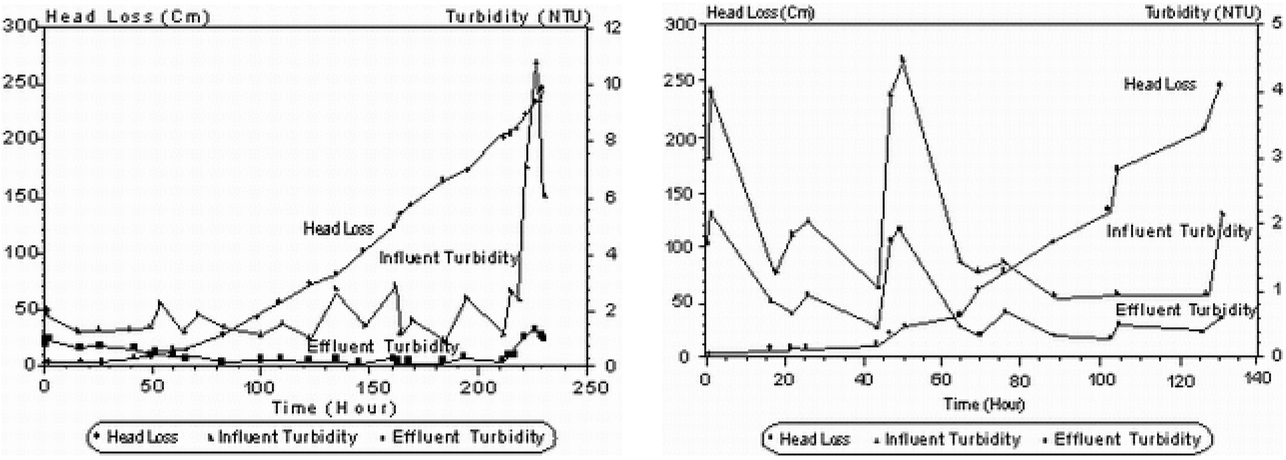


Figure 5a and 5b: Variation of turbidities and head losses for BOPS filter.



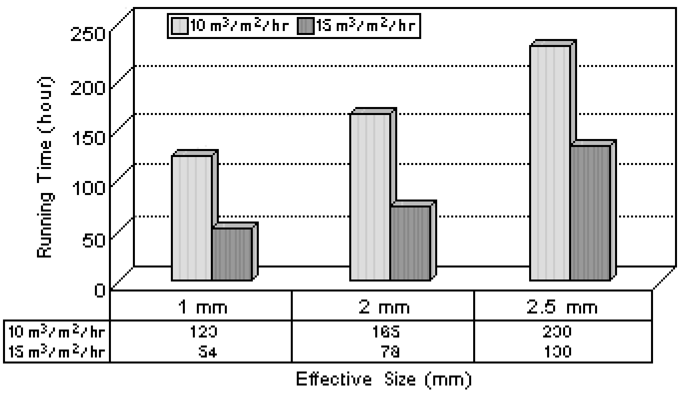
BOPS provides longer running time, as much as three to five times longer than sand (2) and it also allows a higher flow rate (i.e., 15 $m^3/m^2/hr$) as compared to sand filter.

Figure 6 shows the relationship between total filter runs and effective sizes at two different flow rates, mentioned earlier. The total running time at the higher flow rate (15 $m^3/m^2/hr$) is shorter than that at the lower flow rate (10 $m^3/m^2/hr$) for the same effective size. This is as anticipated because at the higher flow rate, the filter is loaded with a higher suspended solids content in a shorter period of time. The result shows that an average reduction of 50 percent in the total filter run occurs as a result of increase in the flow rate from 10 $m^3/m^2/hr$ to 15 $m^3/m^2/hr$ for all effective sizes mentioned.

CONCLUSIONS

The results obtained indicate that the optimum depth of BOPS filter medium reduces with the reduction in effective sizes; the effective depth for effective sizes of 1.0, 2.0 and 2.5 are 60, 80 and 90 cm respectively. Effective sizes of BOPS filter medium of less than 2.00 mm could produce effluent turbidity of less than 1 NTU. A longer filter run is achieved with higher effective sizes. An increase in flow rate 50 % resulted in reduction of filter run by half.

Figure 6: The relationship of running time at various effective sizes for BOPS filter.



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Correspondence:
Ahmad Jusoh
Department of Civil Engineering,
University Pertanian Malaysia,
43400 UPM,
Serdang, Sulangor,
MALAYSIA.