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COMMUNICATION V

Effects of Effective Size in Rapid Sand Filtration

ABSTRAK

Kajian mengenai proses penurasan pasir laju telah dijalankan di Loji Rawatan Air Sungai Langat. Ianya bertujuan untuk menilai kesan saiz efektif media pasir terhadap kekeruhan, masa operasi dan kadar aliran. Kertas kerja ini mengutarakan penemuan daripada kajian tersebut. Hasil daripada kajian didapati tiada perubahan yang ketara dalam nilai kekeruhan selepas dituras untuk saiz efektif di antara 0.4 - 0.9 mm. Walau bagaimanapun masa operasi bertambah untuk saiz efektif yang lebih besar. Di samping itu, masa operasi juga dipengaruhi oleh perubahan kadar aliran, di mana pertambahan kadar aliran sebanyak 50% telah menghasilkan pengurangan masa operasi selama 2 jam untuk setiap saiz efektif yang dikaji.

ABSTRACT

A study on the effects of effective size of sand media in a rapid filtration process with respect to turbidity, filter run and flow rate was carried out at Sungai Langat Water Treatment Works. The findings of the study show no significant difference in the final turbidity achieved with effective sizes (E) range between 0.4 and 0.9 mm. However, filter run increases with higher effective sizes. Filter run is also affected by a change in flow rate a 50% increase in flow rate results in the reduction of filter run by two hours for the effective sizes studied.

INTRODUCTION

Rapid filtration is mainly a physical and chemical process for removing suspended impurities from water by passage through porous media normally by action of gravity resulted from the head difference. The main processes involved can be summarised as straining, flocculation and sedimentation.

Fitration rates of a rapid sand filter lie in the range of 120-300 m^3/m^2/day (Fair *et al.* 1968 and Clark *et al.* 1977). The higher filtration rates enable the space requirement for a rapid filtration unit to be reduced to as much as 20% of that required by a slow sand filter (Schulz & Okun 1984). This is, however, achieved at the expense of the would be biological process of a slow sand filter.

Rapid sand filtration is not a new process and in fact almost all the major water treatment plants in Malaysia employ such a process unit. However, the appropriateness of the filter media and the efficiency of the process can still be upgraded. The study undertaken aims at obtaining the effects of effective size of sand media in a rapid filtration process with respect to turbidity, filter run and flow rate.

The study was conducted at Sungai Langat Water Treatment Works utilizing the chemically treated settled water prior to the rapid sand filtration.

MATERIALS AND METHODS

The filter column utilized in the study is fabricated from clear perspex and equipped with backwashing facility as shown in *Figure 1.* The column is designed to operate as a gravity flow process with regulating valves adjusted manually to compensate for the increasing head loss and thus maintaining a constant rate of flow.

Initially, sands of various effective sizes (0.4, 0.6, 0.8 and 0.9 mm) and uniformity coefficient (U) of 1.6 were studied to obtain optimum depths of filtration for each effective size. Common range in U for single-medium sand filters is 1.3 to 1.7 (Hammer 1986). The optimum depth is defined here as the depth of the sand at which turbidity begins to stabilize i.e. no significant reduction takes place. The various effective sizes can be obtained from the particle size distribution curve as shown in *Figure 2*. Also shown in the figure is an example of how to obtain a particular effective size and uniformity coefficient, which in the example are 0.4 and 1.6 respectively. The filter column was operated at the flow rate of 7.1 $m^3/m^2/hr$ until the effluent turbidity becomes stabilized which, from experience normally occurs after 30 minutes. The respective optimum depths of filtration for the various effective sizes are to be utilized in the second stage of the study. Turbidity was the only parameter being measured at this stage.

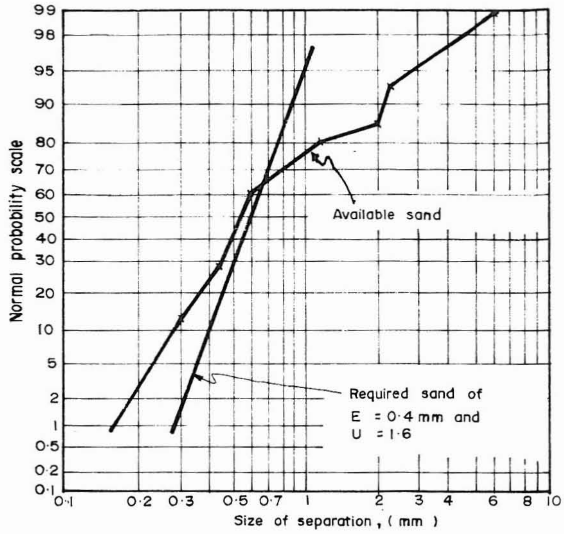

Fig. 2: Particle size distribution of sand media

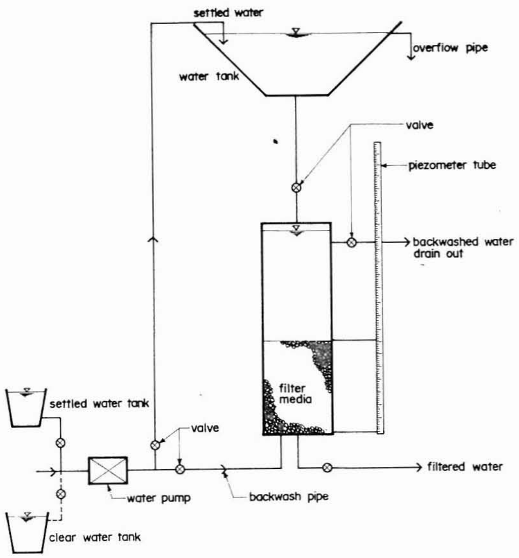

Fig. 1: Layout of the rapid sand filtration system

The second stage involved operating the filter at the optimum depths for all the effective sizes mentioned earlier for a total running time that is, until the measured filter head loss was 2.5 m, as per normal practice (Linsey 1979). Backwashing was then carried out prior to the subsequent operations. Two different flow rate were used, that is 4.7 $m^3/m^2/hr$ and 7.1 $m^3/m^2/hr$. Turbidity, head loss and filter run were monitored.

RESULTS AND DISCUSSION

Figure 3 shows the relationships between the effective sizes and their respective optimum depths. For all affective sizes, turbidity reduces gradually and later flattens out as it approaches the optimum depth. The smaller the effective size the lower is the effluent turbidity achieved. However, at optimum depth the difference is insignificant. It can be seen that optimum depth reduces with the reduction in effective size as shown by the line of optimum depth in the figure.

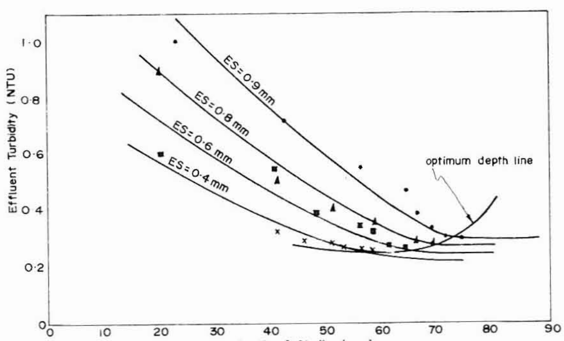

Fig. 3 Relationship between effluent turbidity and depth of media for various effective sizes.

Figures 4 to *11* show the variations of turbidities and head losses with respect to filter run at flow rates of 4.7 $m^3/m^2/hr$ and 7.1 $m^3/m^2/hr$. Effluent turbidity was not affected by the fluctuation in influent turbidity of less than 5

NTU which was the maximum turbidity value recorded while conducting the study for all the effective sizes. In fact the effluent turbidities lie within the narrow range of 0.1 to 0.2 NTU which is not significantly different. This is within the limit recommended by WHO for drinking water quality which is less than 1 NTU for effective disinfection (WHO 1984). The filter run increases with the increase in effective size. Higher effective sizes will therefore allow fewer backwashings and subsequently reduction in the operation cost due to a longer filter run. As expected, for all effective sizes the head loss increases gradually at the earlier stages and rapidly towards the end of the filter run.

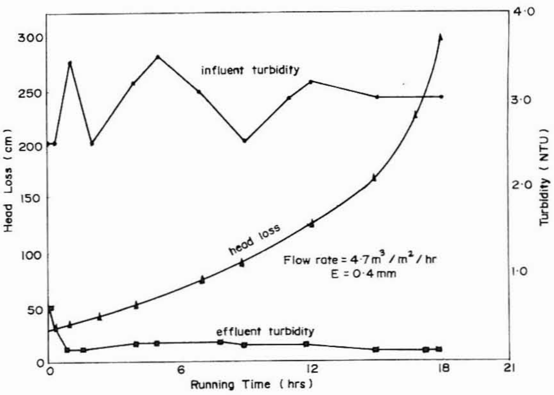

Fig. 4: Variation of influent turbidity, effluent turbidity and head loss with respect to filter run

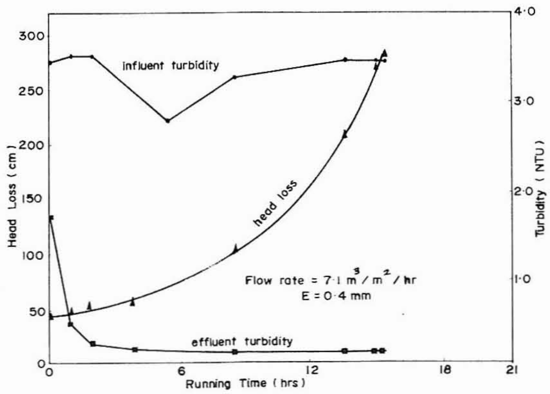

Fig. 5: Variation of influent turbidity, effluent turbidity and head loss with respect to filter run

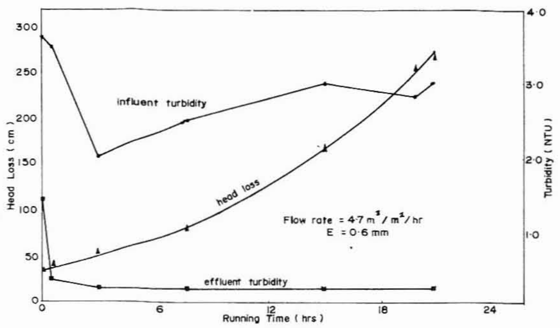

Fig. 6: Variation of influent turbidity, effluent turbidity and head loss with respect to filter run

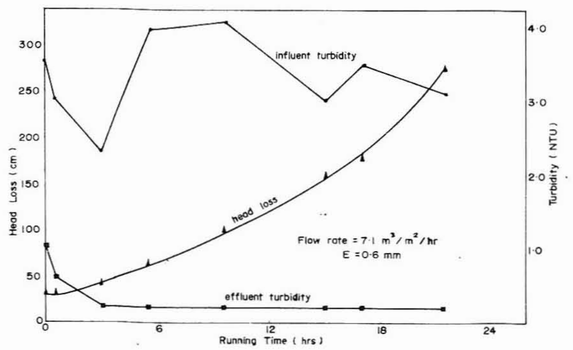

Fig. 7: Variation of influent turbidity, effluent turbidity and head loss with respect to filter run

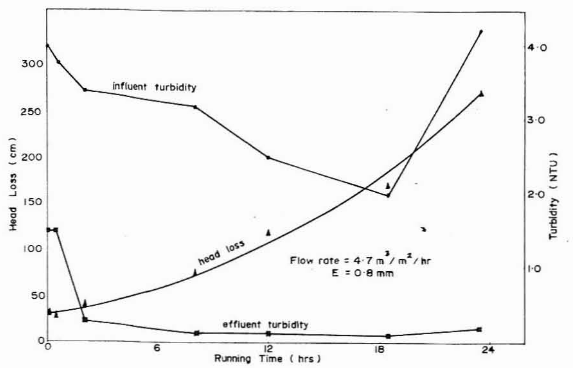

Fig. 8: Variation of influent turbidity, effluent turbidity and head loss with respect to filter run

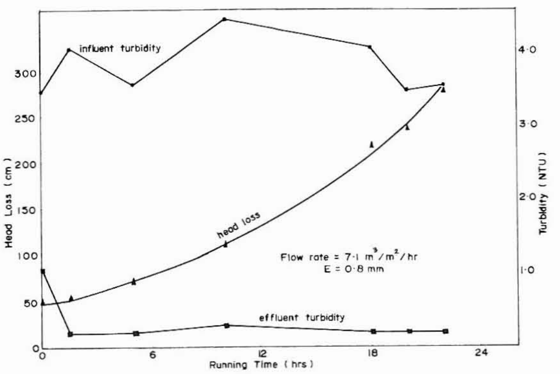

Fig. 9: Variation of influent turbidity, effluent turbidity and head loss with respect to filter run

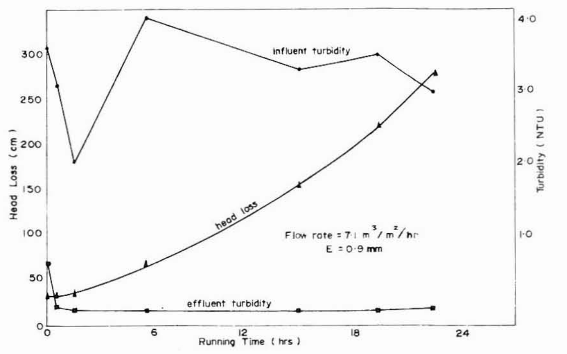

Fig. 11: Variation of influent turbidity, effluent turbidity and head loss with respect to filter run

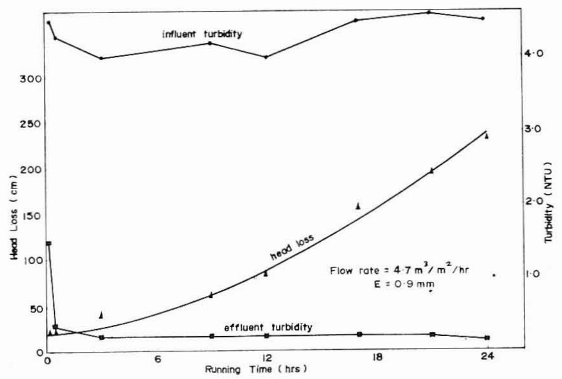

Fig. 10: Variation of influent turbidity, effluent turbidity and head loss with respect to filter run

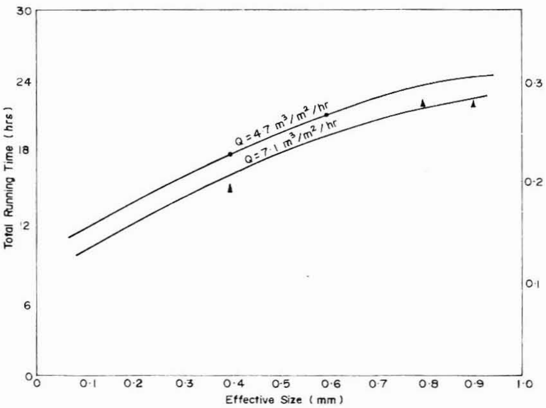

Fig. 12: Variations in total running times at two different flow rates for different effective sizes.

Figure 12 shows the relationship between the total filter run and the effective size at the two different flow rates as mentioned earlier. The total running time at the higher flow rate (7.1 $m^3/m^2/hr$) is shorter than that at the lower flow rate (4.7 $m^3/m^2/hr$) 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 study shows that an average reduction of 2 hours in the total filter run occurs as a result of a 50% increase in the flow rate (from 4.7 $m^3/m^2/hr$ to 7.1 $m^3/m^2/hr$) for all cases.

CONCLUSION

The results obtained indicate that the optimum depth of filter media reduces slightly with the reduction in effective size. Variation in inlet turbidity of less than 5 NTU is not a contributing factor to the final turbidity. A longer filter run is achieved with higher effective sizes. An increase in flow rate of 50% resulted in a minimal reduction of the total filter run.

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