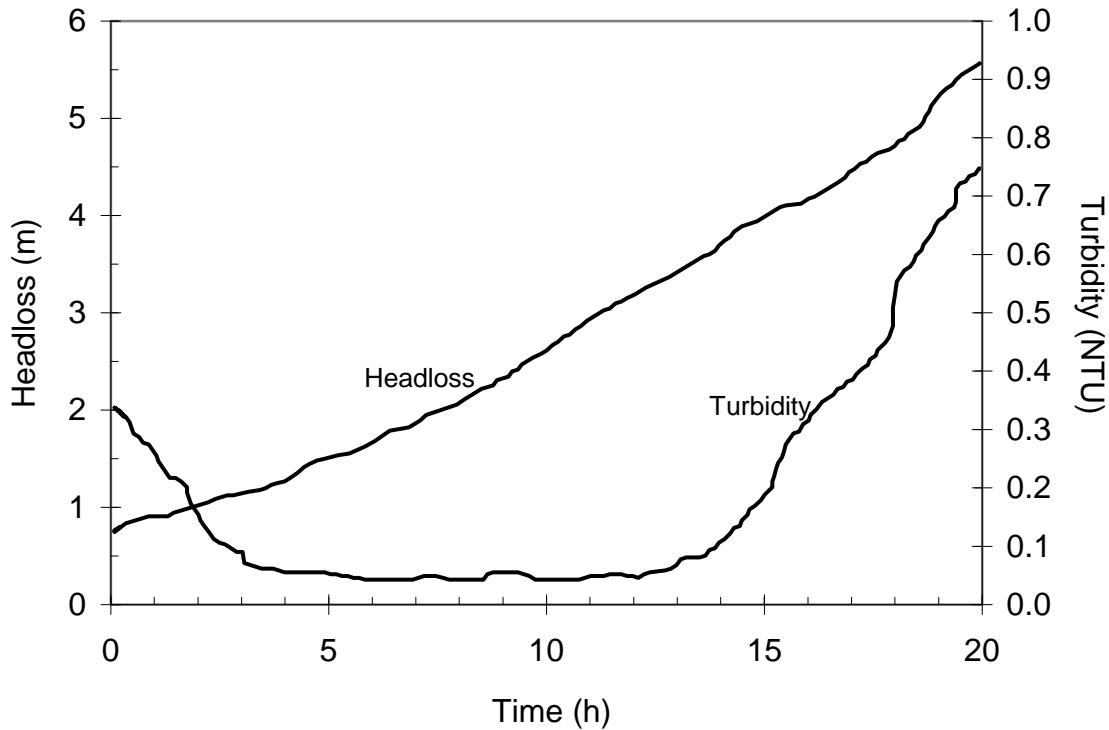


#### CEE 483, Winter 2009, Homework #4

1. A rapid sand filter is used to treat an influent containing 1 mg/L of suspended solids, with an average density of  $1.2 \text{ g/cm}^3$ . The filter has a depth of 60 cm and porosity of 0.39, and water is applied at a superficial velocity of 5 m/h. A run lasts for 20 hours before the maximum allowable headloss is reached. Assuming that essentially all of the particles in the influent are removed by the filter, what fraction of the filter pore volume is occupied by the removed particles at the end of the run?
2. The operating conditions during a typical filter run at a drinking water treatment plant are shown below. The maximum headloss at which the filter can be operated efficiently is 5 m, and the turbidity criterion is 0.2 units. Give a brief explanation with each of your answers.
  - (a) Approximately how long should the operator run the filter before backwashing it?
  - (b) Describe the likely effects of the following changes on the amount of water that can be processed in a filter run.
    - (i) Adding a polymeric coagulant as the water enters the filter bed (assume that the polymer makes the particles more “sticky.”)
    - (ii) Adding sand to the bed to make the column deeper.
    - (iii) Replacing the sand in the bed with larger-grained material, thereby increasing the pore size.
  - (c) On a copy of the plot, sketch new curves showing the expected headloss and turbidity if option *i* (coagulant addition) is implemented.
  - (d) On another copy of the plot, sketch new curves showing the expected headloss and turbidity if option *ii* (sand addition) is implemented. Assume that the additional sand increases the bed depth by 15%.



3. Consider a filter with the following characteristics:

Filtration velocity (velocity of water above the bed): 0.25 cm/s

Depth of sand bed: 45 cm

Density of sand: 2.65 g/cm<sup>3</sup>

Diameter of sand grains: 0.5 mm

Porosity of sand bed: 0.40

Surface dimensions of bed: 6m x 6m

Water temperature: 20°C, at which  $\rho_w = 1.0 \text{ g/cm}^3$ , and  $\mu_w = 1.002 \times 10^{-2} \text{ g/cm-s}$ .

Plot the concentration as a function of depth in the filter for each of the following three types of particles. Compare and comment on the effectiveness of the different removal mechanisms for the different particles. Note: Boltzmann's constant is  $1.38 \times 10^{-16} \text{ (g-cm}^2\text{)/(s}^2\text{-K)}$

(a)  $\rho_p = 1.0 \text{ g/cm}^3$ ,  $d_p = 6 \text{ }\mu\text{m}$

(b)  $\rho_p = 1.6 \text{ g/cm}^3$ ,  $d_p = 6 \text{ }\mu\text{m}$

(c)  $\rho_p = 1.6 \text{ g/cm}^3$ ,  $d_p = 0.2 \text{ }\mu\text{m}$