The Hong Kong Polytechnic University
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Laboratory Worksheet P5 : **Filterability (Flow Through Porous Media)**.

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Objective : To assess the filterability of suspension and to investigate the effect of coagulation on the filterability.

Introduction

Filtration is employed for the removal of suspended solids from low suspended solids water samples. In Hong Kong, sand filtration is employed in drinking water treatment plant to remove suspended solids from the effluent after the coagulation and sedimentation processes. Suspended solids are removed on the surface of a filter by straining, and through the depth of a filter by both straining and adsorption. Adsorption is related to the zeta potential on the suspended solids and the filter media. The efficiency of the filtration process is a function of :

1. The concentration and characteristics of the solids in suspension.
2. The characteristics of the filter media.
3. The mode of filter operation (gravity or pressure).

Filtration rate will affect the buildup of head loss and the effluent quality. The optimum filtration rate is defined as the filtration rate that results in the maximum volume of filtrate per unit filter area while achieving an acceptable effluent quality. High filtration rate will allow solids to penetrate the coarse media and accumulate on the fine media, while low filtration rate is insufficient to achieve good solid penetration of coarse media, resulting in head loss buildup at the top of the filter media.

Improved suspended solids removal can be obtained by the addition of coagulants to the water sample prior to filtration. The use of alum also results in the precipitation and removal of phosphorus through the filter.

The properties of a filter system can be described by the Filterability Index, F, which is defined as :

$$F = \frac{H \times C}{V \times C_0 \times t}$$

where H = Head loss through the filter.

C = Average filtrate quality

C_0 = Input suspension quality

V = Flow velocity approaching the top of the bed

t = Duration of filter run

Filterability Index is dimensionless (if we use consistent unit) and the value of C/C_0 is simply a ratio relating input and output water quality in some way (e,g, turbidity or suspended solids). A low value of F indicates a very good filterability. It is easily seen that for good filtration behaviors, values of H and C should be small and V should be large. It is also clear that increasing t will improve the filterability properties of a filter system but will also implies longer run time. The numerical value of F has no physical significance but relative values of F between various suspensions for the same filter system enable engineers to access the pretreatment quality.

Apparatus and Materials

- Water samples of different suspension quality.
  Different suspension concentrations of Kaolin clay in water will be used in the test. Shake your sample thoroughly before running the filtration test.
- Coagulant
- Stop watch
- Apparatus to determine suspended solids or turbidity
- *Armfield Filterability Apparatus*
  The Armfield Filterability Apparatus, Fig. 1, is used in this test. As the test is of a comparative nature, only the ratio between input and output quality is required and a number of indicators could be used.

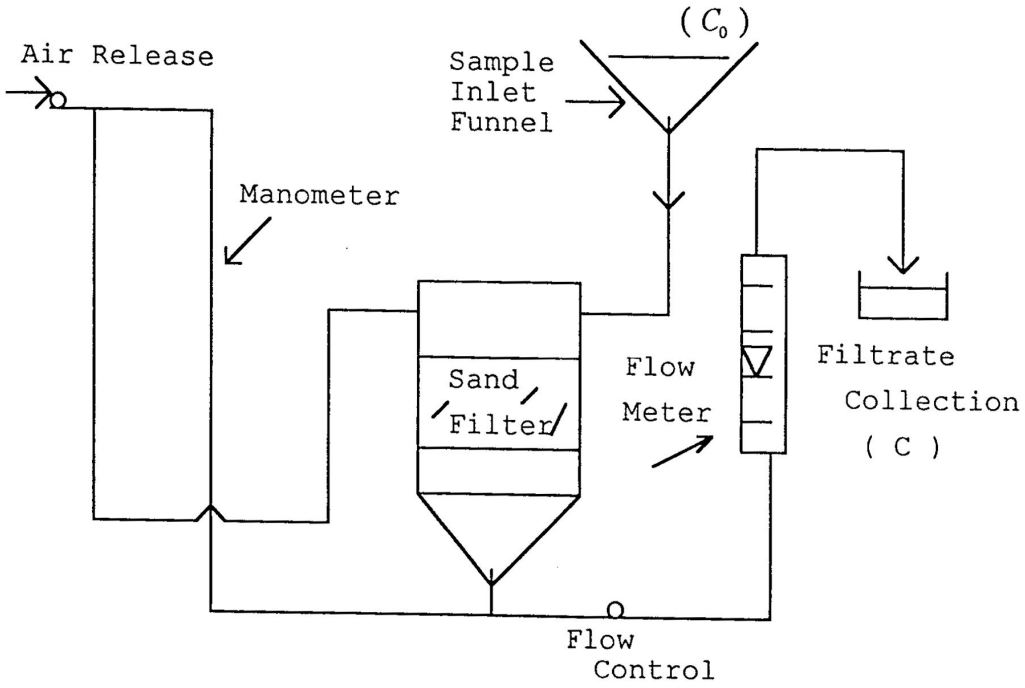

Fig. 1. Armfield Filterability Apparatus.

Filter Media Preparations

72 g dry weight of 0.55 mm dia. sand was packed into the filter column. This should enable a column of 38 mm dia. and 40 mm depth with 40% porosity sand filter to be established. The sand should be thoroughly wetted with water before packing into the column. The apparatus should then be filled with water by reverse flow up to the level of the base of the inlet funnel. All air bubbles must be evacuated from the apparatus through the air releasing screws.

Procedure

1. Measure 1 L of water sample.
2. Fill the inlet funnel with the water sample carefully.
3. Start the influent flow by opening the flow control valve and adjust to 100 mL/min. Start the stop watch.

4. Note that at this flow rate, a period of 40 sec. must be elapsed before the sample starts to pass through the media. Only when the suspension starts to pass through the media is the test deemed to have started (i.e. $t = 0$). Thus, the true duration, t, of a run is : $t = T - 40$, where T is the total run time.

5. By adjusting the flow control valve, keep the flow rate constant.

6. When the sample in the inlet funnel has fallen to the base of the funnel, turn off the valve and the test is completed. Record the total run time T (this should take about 10 min.).

7. Before the test stop, a sample of the influent and effluent should be collected of quality analysis.

8. The head loss through the filter media should be recorded from the manometer near the end of test just before closing the flow control valve.

9. Repeat the test with different water sample quality and dose of coagulant. Suggested alum dosages : 10mg/L, 20mg/L, 40mg/L, 60mg/L, 80mg/L, 100mg/L, 150mg/L.

Discussions

Consider the likely accuracy of the procedures adopted and suggest how to improve it. Discuss the influence of coagulant on the filterability.

Reference

1. Instruction Manual for Armfield Filterability Apparatus.

2. Chemistry for Sanitary Engineers, Sawyer & McCarty.

3. Industrial Water Pollution Control, 2nd Edition, W. Wesley Eckenfelder, Jr., McGraw-Hill, 1989.