# FILTRATION TECHNOLOGIES IN WASTEWATER TREATMENT

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**Keywords:** Deep bed filtration, rapid filters, direct filtration, microfiltration, precoat filtration, cartridge filtration

## Contents





## Summary

This chapter commences with a discussion on the use of deep bed filtration in wastewater treatment. Deep bed filtration includes rapid filters and direct filters. Rapid filtration is used as the final clarifying step in municipal water treatment plants. There are two types of rapid sand filters; the gravity and pressure types. Conventional water treatment plants generally use unit operations such as rapid mixing, flocculation, sedimentation, filtration, and disinfection. Depending on the quality of the water, one or more unit operations can be eliminated, thereby achieving a cost-effective water treatment. Direct filtration is one such method. Filters used in direct filtration thus differ little from those for conventional treatment in construction. The primary difference is related to solids storage capacity and backwashing requirements. Other related filtration technologies such as cartridge filtration, microstrainer, precoat filtration are also discussed and evaluated.

## 1. Introduction

This chapter commences with a discussion on the use of deep bed filtration in wastewater treatment and introduces other related filtration technologies such as cartridge filtration, microstrainer, precoat filtration.

## 2. Deep Bed Filtration

Deep bed filtration processes have been used in industrial and municipal wastewater treatment, in combination with other unit operations, such as activated sludge, chemical coagulation, oxidation, reduction and ion exchange, etc. The structure of the filter for industrial wastewater treatment is virtually the same as that used for potable water treatment. The filters used in domestic and industrial wastewater treatment are generally made of steel instead of reinforced concrete, to facilitate the movement of the units during augmentation of the treatment facility.

### 2.1 Rapid Filters

Rapid filtration is used as the final clarifying step in municipal water treatment plants. Flocculation and sedimentation is provided as pretreatment units to the rapid filter if the raw water has turbidity in excess of 10-20 NTU for an efficient process. There is practically no biological action in rapid filtration although some nitrification occurs where the filtration velocity is relatively slow, where the oxygen content is adequate, and where the nitrifying bacteria find favorable nutrients in the water.

Table 1 gives the characteristics of the gravity type rapid filters. A diagrammatic section view of a rapid gravity filter is given in Figure 1 (modified from Cowle, 1991).

The filter operates usually 24-36 hours before attaining turbidity breakthrough. When the filter is in filtration mode the influent water passes through the filter medium, the supporting layer, and the underdrain where it experiences an energy loss due to frictional resistance referred to as headloss. When the headloss becomes excessive and beyond 1.5-2.5 m, the filter should be cleaned. During cleaning, the water above the filter is drained until the water lies a few centimeters above the top of the bed when air from a compressed air unit is blown in reverse to the normal flow direction at a rate of about 1-1.5 $m^3$ free air/$m^2$ of bed area, at a pressure of 20-35 $kN/m^2$, for about 2-3 minutes, Figure 2 (modified from Cowle, 1991). The water over the bed quickly becomes very dirty as the air agitates the sand and breaks up and detaches the surface scum and dirt. Following this an upward flow of water is passed through the bed at a velocity high enough to sufficiently expand the bed by about 20-50% and cause the sand grains to be agitated and allow scale and deposits to be washed off them, but not at a velocity so high that the sand grains are carried away in the rising upward of water. The details on the filter operation and cleaning can be found elsewhere, (Vigneswaran and Visvanathan, 1995).

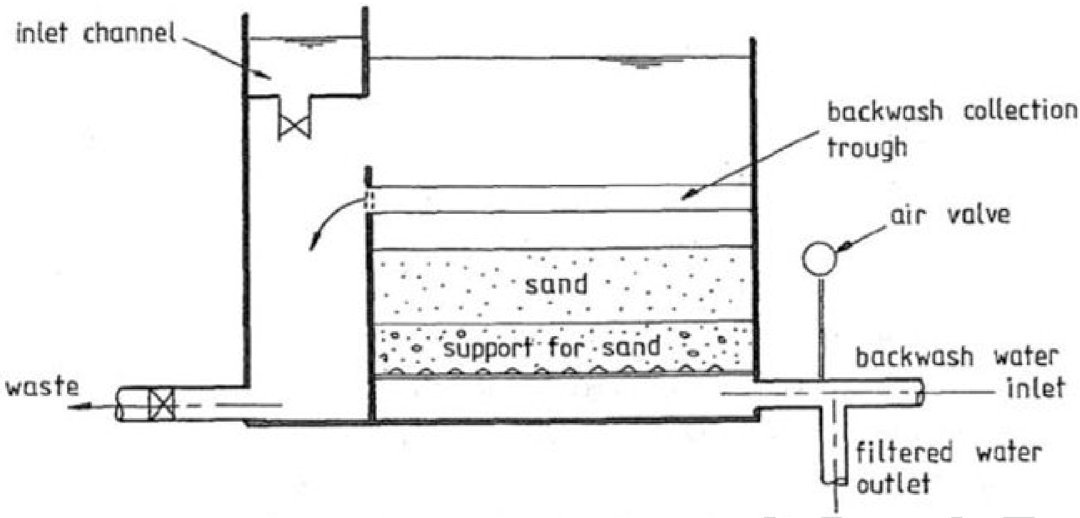


Figure 1 Diagrammatic section of a rapid sand filter.

The entire process of backwashing the filters and restarting the water supply takes about 15 minutes. The specified minimum backwash time for a rapid filter is 5 minutes. The amount of water required to wash a rapid filter may vary from 3-6% of the total amount of water filtered. Upward washwater rates are usually of the order of 0.3-1.0 m/min. The different filter backwash methods and the recommended design values are summarised in Table 2.

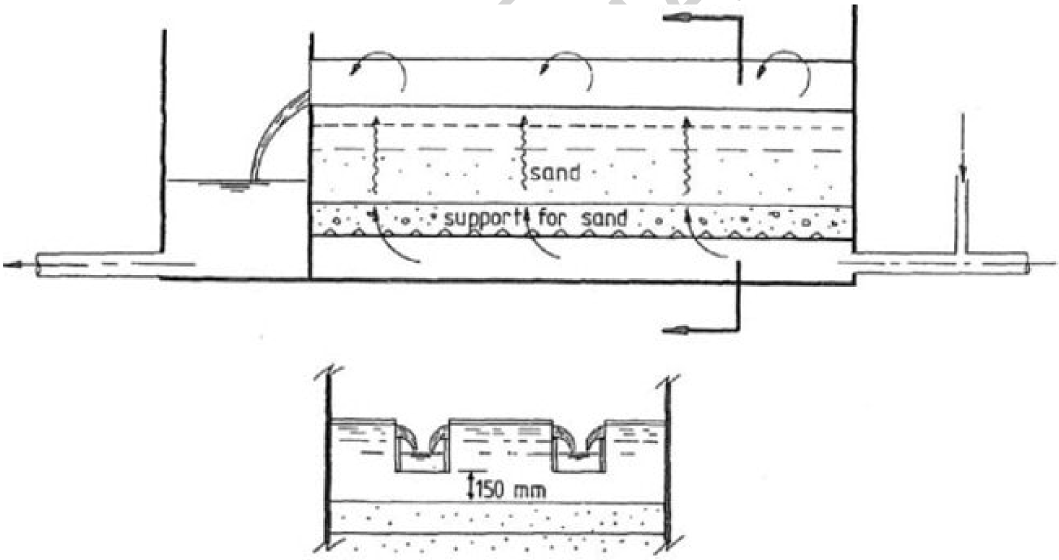


Figure 2 Diagrammatic section of a backwash system.

| **Characteristic** | **Rapid filter** |
|---|---|
| Filtration rate | 120-360 $m^3/m^2d$ |
| Size of bed | Small (100 $m^2$) |
| Depth of bed | 500 mm gravel, 0.7—1.0 m sand, stratified; in some cases sand and anthracite are used as dual media |
| Effective size of sand | 0.6-1.2 mm |
| Uniformity coefficient | 1.5-1.7 |

| | |
|---|---|
| Head loss | Up to 3 m |
| Length of run | 1-2 days |
| Method of cleaning | Backwash with water and air + water scour and in some cases surface scour |
| Washwater consumption | 3-6% of filtered water |
| Penetration of suspended solids through the filter bed | Deep |
| Pretreatment by coagulation | Yes |
| Covered construction | Optional |
| Visible operation | Yes |
| Adjusting the quality of filtrate | Can be done quickly |
| Bacteria removal | 90-99% |

Table 1 Comparison of Slow Sand Filters and Rapid Sand Filters

| **Parameter** | **High-rate water backwash** | **Water backwash with air auxiliary** | | |
|---|---|---|---|---|
| | | **Air scour followed by high-rate water backwash** | **Simultaneous air and low-rate water backwash followed by high-rate water backwash** | **Water backwash with surface wash auxiliary** |
| Backwash rate | 37.5 $m^3/m^2h$ | >18 $m^3/m^2h$ | — | 15-18 $m^3/m^2h$ |
| Backwash water | 2.5-5 $kg/cm^2$ | 2.5-5 $kg/cm^2$ | 2.5-5 $kg/cm^2$ | 0.25-0.5 $kg/cm^2$ |
| pressure | | | | |
| Air scour rate | — | 27 $m^3/m^2h$ | 36-46 $m^3/m^2h$ | — |
| Surface wash rate | — | — | — | 10—12 $m^3/m^2h$ |
| Pressure of surface | — | — | — | 1.5—4 kg/cm2 |
| scour water | | | | This type of filter backwash is used when mud ball formation occurs on the top of filter bed |
| Porosity range during expansion | 0.68-0.70 | — | — | |
| Expansion of medium | 80-100% | Low | Low | — |
| Time of washing | 3-6 mm | 3-4 mm | 2-3 mm | — |
| Time of air scour | — | 3-4 mm | 2-3 mm | — |
| application | | | | |

| | | | | |
|---|---|---|---|---|
| Amount of wash | High | High | High | High |
| water needed | | | | |
| Efficiency of cleaning | Poor | Good | Good | — |
| action | | | | |
| Applicability | Single and multimedia filters | Single and multimedia filters | Single and multimedia filters | Single media filters |

Table 2 Recommended Design Values for Various Backwash Methods

The media size (D) and depth (L) of filter media depends on the raw water quality and the required filter run. The ratio of L/D is usually in the range of 800-1000 for potable water treatment. However, in wastewater treatment, a lower L/D ratio of between 500-700 is common. In most cases, the media size is coarser and the depth larger compared to those used in potable water treatment. A dual-media filter consisting of anthracite and sand is often used to reduce the rate of pressure drop and improve the filtrate quality. Backwashing of the filter is combined with surface washing and/or air scouring.

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**Biographical Sketches**

**Dr S. Vigneswaran** has been working on water and wastewater treatment and reuse related research since 1976. During the last twenty years, he has made significant contributions in physico-chemical water treatment related processes such as filtration, flocculation, membrane-filtration and adsorption. His research activities both on new processes development and mathematical modeling are well documented in reputed international journals such as Water Research, American Institute of Chemical Engineers Journal, Chemical Engineering Science, Journal of American Society of Civil Engineers, and Journal of Membrane Science. He has also been involved in a number of consulting activities in this field in Australia, Indonesia, France, Korea, and Thailand through various national and international agencies. He has authored two books in this field at the invitation of CRC press, USA, and has published more than 230 papers in journals and conference's proceedings. Currently a Professor of the Environmental Engineering Group at the University of Technology, Sydney, he was the founding Head of and the founding Co-ordinator of the University Key Research Strength Program in Water and Waste Management. He is coordinating the Urban Water Cycle and Water and Environmental Management of the newly established Research Institutes on Water and Environmental Resources Management and Nano-scale Technology respectively.

**Dr J. Kandasamy** is currently a Senior Lecturer in the Faculty of Engineering University of Technology, Sydney, Australia. He obtained his PhD from University of Auckland., New Zealand where is also obtained his Bachelor in Civil Engineering and Masters in Civil Engineering. He has worked in the New South Wales Government as a Senior Engineer for 15 years and has wide industry knowledge.

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