

Rapid sand filtration

Sedimentation with or without coagulation and flocculation will not give adequate water quality. The production of clear water requires the use of a filter.

There are two principal types of filter for community water supply : rapid filters and slow sand filters. Slow sand filters are very efficient in removal of microorganisms from water. They are described in Fact Sheet 2.12. Rapid filters are used primarily to remove turbidity after coagulation and flocculation in large water treatment plants.

Rapid filters can either be open tanks (rapid gravity filters, see Figure 1) or closed tanks (pressure filters, see Figure 2), where water passes through a filter medium, most commonly sand.

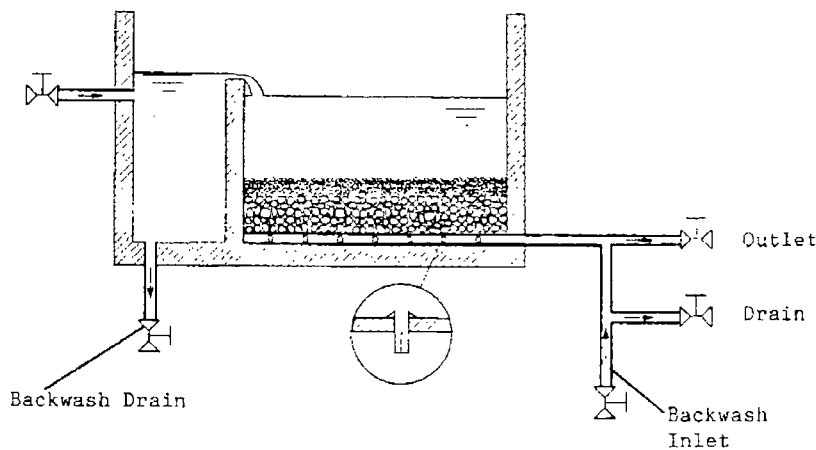


Figure 1. Rapid gravity filter

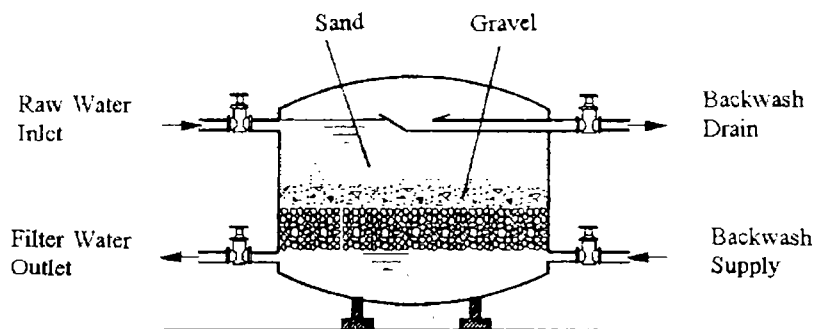


Figure 2. Pressure filter

Water is supplied to the top of a bed of sand, supported on a bed of graded sand and gravel on a system of underdrains. In order to force the water through the sand, a depth of about 1.5 to 2 metres of water must be maintained above the sand. The filtering action of the sand is entirely mechanical and suspended matter is accumulated in the spaces between sand grains until the output of water drops too low. At this point, the filter is drained and cleaned by backwashing.

The necessity for frequent backwashing requires trained staff and frequent checking. However, as rapid gravity filters are compact and efficient, they are very suitable for large installations on restricted sites.

In large urban water supplies, the most commonly used filtration units are rapid gravity sand filters. This process is part of a system which includes coagulation, flocculation, clarification and disinfection.

A well-operated rapid filter will reduce turbidity to less than 1 TU and often less than 0.1 TU. Rapid filtration is not very efficient in removing microorganisms, although some are removed, and should therefore be followed by terminal disinfection.

Backwashing open tank filters generally requires the use of filtered water from a raised storage tank or pumped from the system directly for backwashing purposes. When multiple pressure filters are installed, treated water from one may be used to backwash another. Backwash water is a source of contamination and should not be discharged directly into a river or stream. It is normally discharged into a sewerage system or stabilization ponds. Alternatively, it can be treated and recirculated, if this proves to be cost effective.

Sanitary inspections of rapid filters

Sanitary inspections should be conducted regularly to ensure that filters are functioning properly and that an adequate water supply is being maintained (see Fact Sheet 2.1). The key points and observations to make during an inspection are :

- Check the filtration rate through the filter ; this should not exceed the design flow of 5 - 12 metres per hour.
- Check the rate and frequency of backwashing to ensure that the filter is being properly cleaned.
- Check the sand depth to see whether sand is being lost during cleaning.
- Check for mud balls and cracking in the sand bed. If these are found, then the sand may need replacement or backwashing with air and water. Seek expert advice.
- Check outlet turbidity and influent turbidity. There should be over 90 per cent reduction in turbidity.

- Check whether there is sand in the clear water well and gravel on the surface of the filter bed. These indicate problems with the underdrains which will need to be replaced.

Operation and maintenance of rapid filters

The operation and maintenance of rapid filters requires some skill, and it should be clear who is responsible for what activities. Maintenance should be regular and planned, in particular the turbidity of treated water and the head loss should be carefully monitored. A complete record should be kept of inlet and outlet water turbidity, head loss and cleaning to ensure that the filter functions efficiently and that an adequate water supply is maintained. The following points cover the key aspects of rapid filters and their operational and maintenance needs.

Raw water quality

A rapid filter will not efficiently remove fine suspended solids. It is therefore essential that coagulation and flocculation be performed prior to rapid filtration. Coagulation and flocculation are described in Fact Sheet 2.13.

Filter medium

Coarse (effective size 0.5-1.0 millimetre) sand is the most commonly used filter medium in rapid filters. Some filters contain a mixture of sand and larger particles of anthracite (effective size about 1 millimetre). After backwashing, the larger, lighter anthracite particles settle on top of the sand. Water is therefore filtered consecutively through coarse anthracite and then less coarse sand ; this enables longer filter runs between cleaning. The depth of the medium in the filter should be 0.5 to 1.0 metres.

Rate of filtration

Flow rates in rapid filters vary widely ; many installations are designed to operate at a downward water velocity in the filter bed of 4 to 12 metres per hour.

Cleaning

Rapid filters clog fairly quickly because of the high rates of filtration. Typically, they are cleaned every few hours or days. Cleaning may be automatic in large water treatment plants. As the filter operates, it removes suspended matter from the water. Eventually this matter clogs the filter and the flow is reduced. The difference between the level of water above the sand bed and the pressure at the outlet, known as “ head loss ”, will increase (see Figure 3). Cleaning is generally undertaken when the head loss reaches an unacceptable level (for instance 2.5 metres) or when treated water quality deteriorates. This can be readily assessed by regularly monitoring turbidity (see Fact Sheet 2.33). Rapid filters are normally cleaned at regular intervals (every 24 to 72 hours).

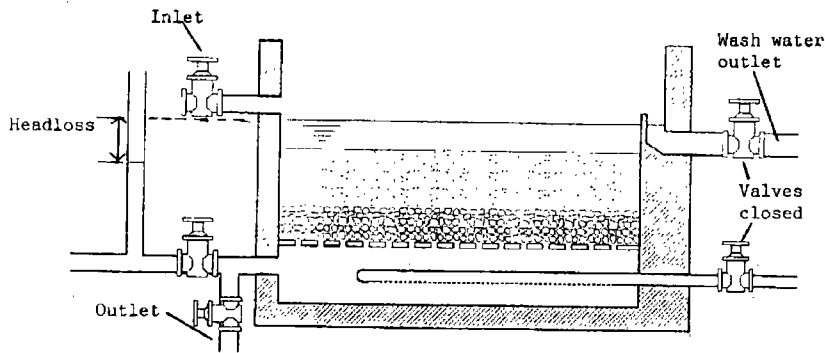


Figure 3. Head loss in a rapid gravity filter

When a rapid filter needs cleaning, this is done by backwashing. The flow of water is reversed so that treated water is forced up through the filter bed. The sand is re-suspended or “fluidized” in the flow of water but the gravel support layers are undisturbed and the solid matter is separated in the surface wash water. The rate of flow of backwash water must be carefully controlled to make sure that the filter medium (sand) is not washed away. This method of cleaning a rapid sand filter is shown in Figure 4.

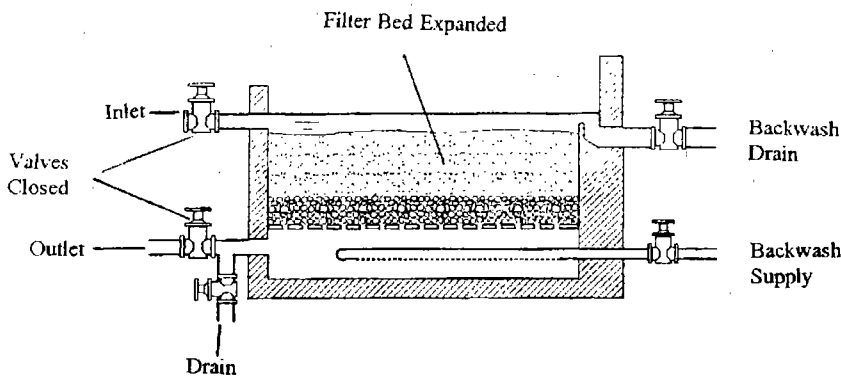


Figure 4. Cleaning a rapid gravity filter

When cleaning is finished (typically after 5 to 10 minutes of backwashing) the backwash flow is stopped and normal flow is resumed. In some systems, cleaning is assisted by injecting air with the backwash water or by mechanical mixing.