6.5 Filtration

6.5.1 General

Turbidity and algae are removed from raw waters by screens, gravel filters and slow sand or rapid gravity filters. The difference between slow and rapid sand filtration is not a simple matter of the speed of filtration, but in the underlying concept of the treatment process. Slow sand filtration is essentially a biological process whereas rapid sand filtration is a physical treatment process.

6.5.2 Screens

Screens are effective for the removal of particulate material and debris from raw waters and are used on many surface water intakes. Coarse screens will remove weeds and debris while band screens or microstrainers will remove smaller particles including fish and may be effective in removing large algae. Microstrainers are used as a pre-treatment to reduce solids loading before slow sand filters or chemical coagulation. A microstrainer consists of a rotating drum fitted with very fine mesh panels. Raw water flows through the mesh and suspended solids including algae are retained and removed by water wash, producing a wastewater, which may require treatment before disposal.

6.5.3 Gravel filters

Gravel filters may be used to remove turbidity and algae. A simple gravel filter for the protection of a stream or river inlet is described in Section 3.4.1. A larger gravel filter may consist of a rectangular channel or tank divided into several sections and filled with graded gravel (size range 4 to 30 mm). The raw water enters through an inlet distribution chamber and flows horizontally through the tank, encountering first the coarse and then the finer gravel. The filtered water is collected in an outlet chamber. Solids removed from the raw water accumulate on the floor of the filter. Gravel filters can operate for several years before cleaning becomes necessary. The size of a gravel filter will depend on water quality, flow rate and size of gravel. A filter can be up to 12 m long, 2 to 5 m wide and 1 to 1.5 m deep. The filter should normally be sized for a flow rate of between 0.5 to 1.0 cubic metres per square metre of filter surface area per hour ($m^3/m^2.h$).

6.5.4 Slow sand filters

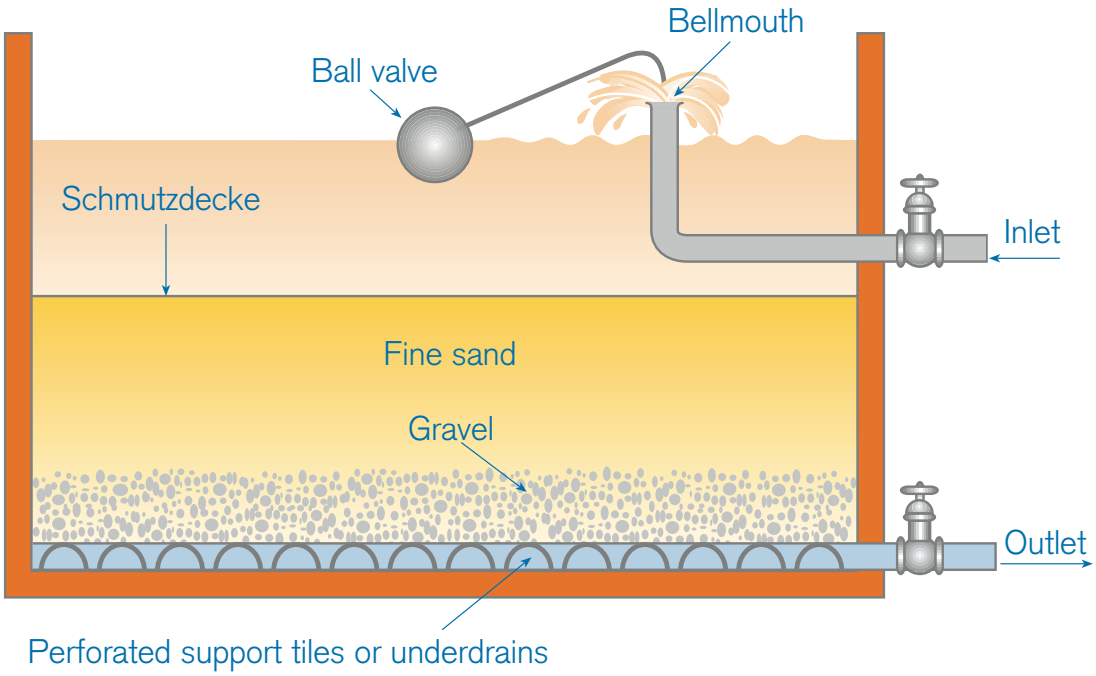
Slow sand filters, sometimes preceded by microstraining or coarse filtration, are used to remove turbidity, algae and micro-organisms. Slow sand filtration is a simple and reliable process and is therefore often suitable for the treatment of small supplies provided that sufficient land is available.

Slow sand filters usually consist of tanks containing sand (size range 0.15-0.30 mm) to a depth of between 0.5 to 1.5 m. For small supplies, modular units of 1.25 m diameter are available – a tandem installation would occupy a concrete apron of about 8 to 10 m^2. The raw water flows downwards and turbidity and micro-organisms are removed by filtration in the top few centimetres of the sand. A biological layer of sludge, known as the 'schmutzdecke', develops on the surface of the filter that can be effective in removing micro-organisms. Treated water is collected in underdrains or pipework at the bottom of the filter. The top few centimetres of sand containing the accumulated solids are removed and replaced periodically. Filter runs of between 2 and 10 weeks are possible, depending on raw water quality and flow rate. Slow sand filters are often operated in tandem; one in service whilst the other is cleaned and time allowed for the schmutzdecke to re-establish.

A variant of the slow sand filter, the 'Inverness filter' or 'Argyll filter', has been widely used in Scotland. It uses the same grade of sand and operates at the same flow rate as the traditional slow sand filter but the water flows upwards. Filtration is achieved throughout the filter bed and a true 'schmutzdecke' does not develop. The sand is 'washed' by opening a valve at the bottom of the filter and allowing the filter bed to drain rapidly.

Slow sand filters should be sized for a water flow rate of between 0.1 and 0.3 $m^3/m^2.h$. The flow rate should be controlled and the filter designed with a treated water reservoir of sufficient capacity to accommodate fluctuations in demand, and thus permit operation of filters at a steady and continuous rate.

Figure 6.4 Slow sand filter



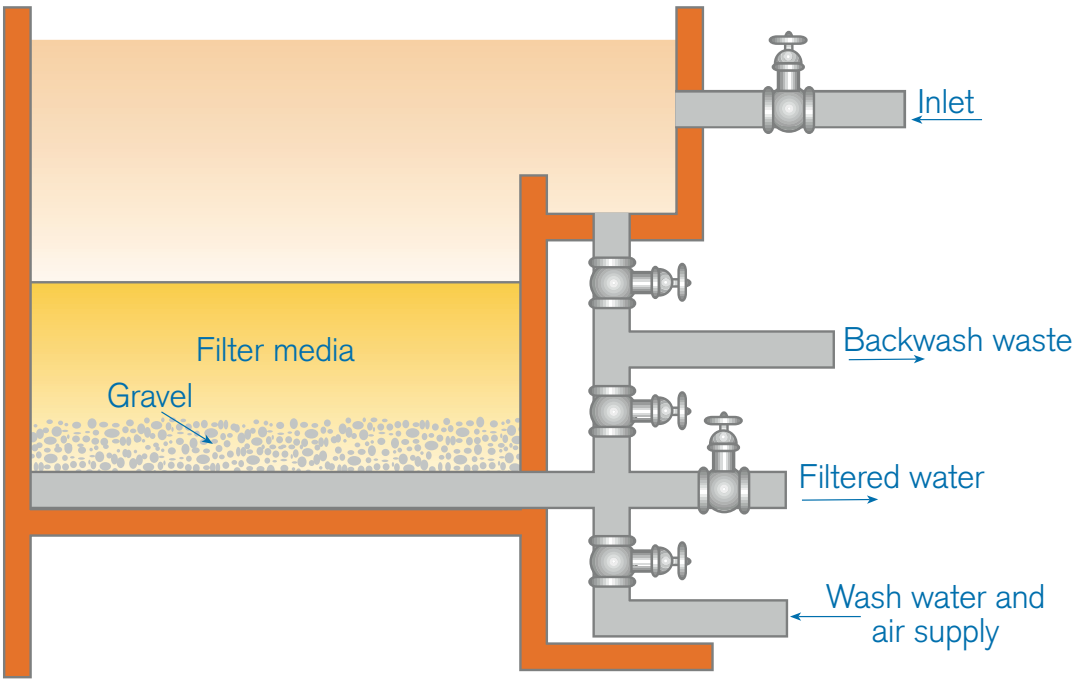
6.5.5 Rapid gravity filters

Rapid gravity filters are most commonly used to remove floc from coagulated waters. They may also be used to remove turbidity, algae and iron and manganese from raw waters. Granular activated carbon medium is used to remove organic compounds and filters incorporating an alkaline medium are used to increase the pH value of acidic water.

Rapid gravity sand filters usually consist of rectangular tanks containing silica sand (size range 0.5 to 1.0 mm) to a depth of between 0.6 and 1.0 m. The water flows downwards and solids become concentrated in the upper layers of the bed. Treated water is collected *via* nozzles in the floor of the filter. The accumulated solids are removed periodically by backwashing with treated water, usually preceded by scouring of the sand with air. Frequency of backwashing depends on loading rate and raw water quality and is typically every 24 hours. Backwashing can be initiated automatically after a pre-determined headloss has been reached or may be carried out manually. A dilute sludge that requires disposal is produced which may be discharged to sewer, soakaway or, after treatment, to a watercourse provided that any required discharge consent is obtained.

A number of proprietary filters contain media of different sizes and densities. In some filters, the raw water flows upwards and improved filtration efficiency is claimed. The size of a rapid gravity filter is determined by the filtration rate if backwashed automatically, or by the solids retention if backwashed manually. Filters should normally have sufficient area to enable them to be operated at no more than 6 m/h at peak flow or to retain 1 kg of solids per square metre of bed between washes at peak loading, whichever is greater.

Figure 6.5 Rapid gravity filter



6.5.6 Pressure filters

Pressure filters are sometimes used where it is necessary to maintain head in order to eliminate the need for pumping into supply. The filter bed is enclosed in a cylindrical shell. Small pressure filters, capable of treating up to about 15 m^3/h, can be manufactured in glass reinforced plastics. Larger pressure filters are manufactured in specially coated steel. Operation and performance are generally as described for the rapid gravity filter (see Section 6.5.5) and similar facilities are required for backwashing and disposal of the dilute sludge. A similar range of contaminants can be removed depending on the filter medium.

Figure 6.6 Pressure filter