4 Filtration of liquids

Filtration is the removal of suspended particles from a fluid, performed by a filter medium, septum, cloth or bed of solids. In this chapter we will discuss only liquid filtration, the removal of particles from gases is covered in Chapter 14. Filtration is commonly encountered in chemistry laboratories on a Buchner funnel and within the kitchen during the making of filter coffee. It is a very important industrial process as it is often a key stage in product recovery: following reaction, precipitation and crystallisation stages, but preceding thermal drying and packaging (e.g. in pharmaceutical production). It is more economic to remove moisture from particles by mechanical means, including filtration, than by thermal means. Thus, domestic washing machines provide higher and higher spin speeds prior to thermal, or evaporative, drying.

There is a vast range of filtration types; depending upon whether the objective is to produce a clean liquid, as in drinking water production, or solids retained in a filter cake, as in product recovery. The former process is called clarification, or clarifying filtration and is often performed in equipment containing packed beds, which were introduced in the previous chapter.

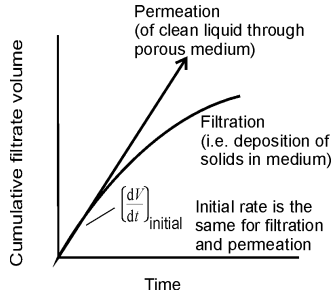

Fig. 4.1 In a filter increasing resistance causes liquid flow to decrease with time – at constant pressure drop

4.1 Deep bed and clarifying filtration

Uses for bed filters
Drinking (potable) water, pretreatment for high purity water, e.g. electronics industry, effluent treatment, beer and wine clarification, sea water filtration before injecting into oil reservoirs.

Deep bed filtration uses packed beds of particles between 300 and 5000 μm in diameter and the bed height is usually between 0.5 to 3 metres. Deposition of suspended solids takes place within the bed, by a variety of particle adhesion and collection mechanisms. Some are discussed in Chapters 13 and 14. The most pertinent are: sedimentation (on to the bed grains), inertia, van der Waals, diffusion, electrostatic attraction and repulsion. Within the bed the fluid flow condition is predominantly laminar – to minimise the scouring effect of turbulences. However, the packed bed will eventually contain a large amount of deposited solids and need regenerating; at this stage a *backflush* is often employed, which may involve inducing fluid turbulences. The frequency of regeneration will depend upon the concentration of solids in suspension entering the bed. This is usually low: less than 0.5 grams per litre. The feed flow rate is usually less than 8 m^3 per m^2 of bed area per hour and it is possible for the bed filter to reduce the outlet (effluent) solids concentration to below 0.1 milligrams per litre. However, when processing very small particles, such as bacteria and viruses, the feed rate may need to be low: 0.1 $m^3\ m^{-2}\ h^{-1}$, in order to provide the effluent quality required; i.e. particle removal.

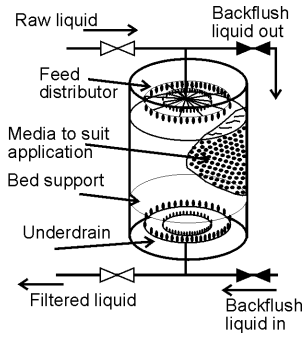

Fig. 4.2 A deep bed filter

As particles are deposited within the packed bed, the resistance to fluid flow increases. If the bed is running under a constant pressure difference the resulting flow rate will diminish, as illustrated in