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The Filtration of Water Supplies*

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Filtration plays an important and fundamental part in the purification of water rendering it fit for human consumption. It is a versatile process and is employed for clarification, for chemical processing and for disinfecting purposes. The principles and practicalities of such filters are described.

Introduction

Filtration is probably the most important unit process in the treatment and purification of water. Of the contaminants found in the multivaried sources of supply it is true to say that, in principle, they could all be removed by a particular filtration process, although in practice other processes are utilised for considerations of economy and convenience.

Figure 1 illustrates the size of contaminants that may be found in water sources and the operating ranges of different types of filters that can be employed for their removal. Our attention is focused on impurities around the 1 μm size and which consist mostly of material that will not settle out unaided under gravity.

Filtration as a Phenomenon

There are two mechanisms whereby matter is removed from a liquid by the process of filtration. The first is a sieving mechanism, analogous to a garden riddle, whereby particles larger than the riddle hole size (the pore size) will be retained on the surface of the mesh and smaller matter passes through. The second mechanism is one of surface adsorption and here the nature of the contaminant and the filter material will determine the efficiency of removal. This will also be affected by the transport of contaminant to the filter surface and by the character and concentration of dissolved materials in the liquid, which will affect the electrostatic properties.

Figure 2 illustrates the performance of the two mechanisms of filtration. In Figure 2(a) it is seen that the filter removes particles down to the pore size, i.e. the filtration efficiency diminishes with decreasing contaminant particle size. Figure 2(b) shows an opposite trend for electrokinetic adsorption whereby the filtration efficiency increases as the particle size becomes smaller, indicative of the greater relative importance of surface effects at smaller sizes.

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The combined effect of these two mechanisms is found in practical filters, whereby the filtration characteristics can be tailored to the practical application.

The pore size of a filter can be controlled by adjusting the grain size of a media filter or the material characteristics of membranes or ceramics. The adsorption can be enhanced by slowing down the rate of flow of the liquid through the filter, or by lengthening the filter itself, thus resulting in more time for contact between an impurity particle and a surface and therefore more probability of adsorption and removal.

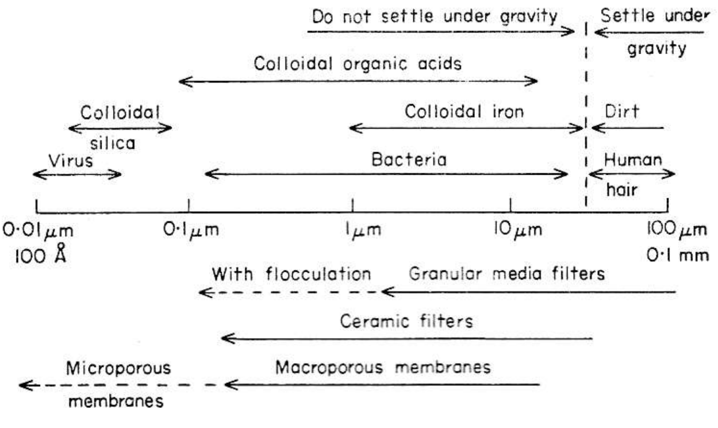

Fig. 1. The sizes of contaminants and operating ranges of filters.

Types of Filter

GRANULAR MEDIA FILTERS

The simplest and most commonly used granular media filter is the sand filter. Sand granules of perhaps 0·5 mm diameter form a filtration bed and a depth of 80–150 cm is employed. Filtration takes place by the mechanisms of straining and adsorption and the whole depth of the filter is utilised. Frequently two types of granules are used in the same filter bed and in particular an upper layer of anthracite enhances the efficiency of the filtration process.

Granules of dolomite ($CaCO_3/MgCO_3$) perform in the same way as sand for the physical removal of particulate matter and will, in addition, raise the pH of acidic waters, by dissolution of the media itself, and assist in the oxidation and precipitation of ferrous matter.

The special porous nature and adsorption properties of granular activated carbon find increasing application for the removal of relatively low molecular weight organic molecules from water. Thus this media is used for filtration in the sub-micrometre range of the microporous membranes rather than in the usual range of other granules.

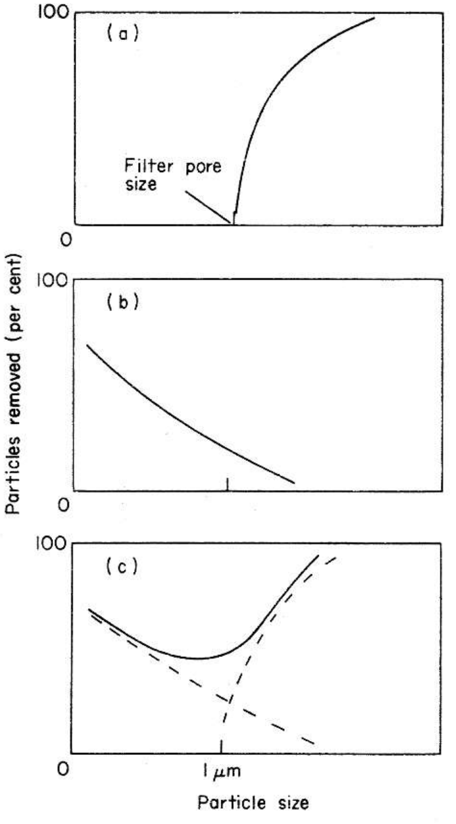

Fig. 2. The mechanisms of filtration. (a) Sieving mechanism; (b) electrokinetic adsorption; (c) combined effect.

STRAINING FILTERS

Straining filters utilise only their surface for the filtration and removal of material. Such filters are plastic membranes and porous ceramics, with closely defined and manufactured pore sizes. Matter larger than the pore size is retained on the surface of the strainer; smaller material passes through with the water.

The delicate nature of the membrane filter does not allow cleaning and re-use, but the ceramic filter may be considered as a series of many membranes one on top of the other. When clogging occurs it is an easy matter to scrub away a thin layer of ceramic to expose a fresh, new surface. The pore size is conveniently defined by the porous nature of the diatomite or Kieselguhr material of construction. This material is composed of the silicified skeletons of ancient diatoms and filtration of the water takes place through the abundant skeletal pores.

Applications of Filters

LOCAL AREA SCALE

On the local area scale filtration as a process is used for the removal of suspended matter, i.e. for the reduction of the turbidity of water. To assist the process and to extend it to the removal of smaller particulate contaminants, the useful range is increased by prior flocculation of the water using aluminium or ferric sulphate, for example. The added chemical enhances agglomeration of colloidal and fine contaminants thus forming larger particulates which are removed, in turn, more readily by a granular filter.

Although the passage of water through a granular sand or mixed media filter will improve the bacterial quality, disinfection is always carried out subsequently by the addition of chlorine or ozone.

DOMESTIC SCALE

Granular media filters find application on the domestic scale for the removal of sediment and suspended matter from water. pH correction and removal of iron is accomplished using granular dolomitic media filters.

Of particular importance and convenience is the disinfection of water on the small scale by filtration. The ceramic filter will remove particulate matter and bacteria with a similar efficiency to a 0·45 μm rated membrane. Indeed, the same test is used to establish the performance of both filters, i.e. the 100 per cent. removal of a suspension of *Serratia marcescens* bacterial organisms. The small pore size and the fact that filtration does take place on the surface of the ceramic can lead to problems with certain waters. Thus clogging may occur with an excess of 2 mg /l of suspended solids, with more than 1 mg /l of colloidal organic matter as measured by the oxygen absorbed, or with more than 0·1 mg/l of total iron. However, the process of scrubbing clean and exposing a new ceramic layer does restore the flow of water without impairing the filtration properties.