

6.7 Chemical treatment

6.7.1 Control of pH

The pH value of water may need to be adjusted during treatment and before distribution for several reasons, including:

- to ensure that the pH value meets the water quality standards;
- to control corrosion in the distribution system and consumers' installations or to reduce plumbosolvency;
- to improve the effectiveness and efficiency of disinfection;
- to facilitate the removal of iron and manganese; and
- to facilitate the removal of colour and turbidity by chemical coagulation.

Many raw surface waters are slightly acidic and coagulation processes further increase acidity. Increase of pH can be achieved by:

- dosing with sodium hydroxide, calcium hydroxide or sodium carbonate;
- passage of the water through a bed of alkaline medium; or
- removal of excess carbon dioxide by aeration.

Where necessary, reduction of pH can be achieved by dosing with a suitable acid such as sulphuric acid, hydrochloric acid, sodium hydrogen sulphate or carbon dioxide.

6.7.2 Iron and manganese removal

In groundwaters, iron is usually present as dissolved ferrous compounds. To remove iron in this form, it is necessary to oxidise ferrous iron, usually by aeration, to the insoluble ferric hydroxide and to remove the precipitated material in a subsequent filtration stage. It is important to ensure that oxidation does not give rise to colloidal species which may pass through the filters. If the iron is present as an organic complex, a strong oxidant such as chlorine or potassium permanganate must be used. Manganese is usually present as dissolved manganous compounds. Removal is achieved by oxidation to insoluble manganese dioxide using catalytic filters or potassium permanganate followed by filtration, or by coagulation at high pH followed by filtration.

In surface waters, iron and manganese are usually present in their oxidised forms and are associated with the suspended solids, which can be removed by filtration. Where coagulation is practised for the removal of colour and turbidity, iron removal may be achieved simultaneously. Iron and manganese may be combined with organic matter in very stable forms. The usual treatment in this case is coagulation followed by oxidation with chlorine or potassium permanganate and filtration.

6.7.3 Taste and odour removal

Taste and odour can be removed by several methods, including aeration, ozonation and adsorption on activated carbon. The method used will depend on the source of the taste and odour. Adsorption on activated carbon is generally the most effective method for the removal of 'earthy' or 'mouldy' taste and odour. Powdered activated carbon can be dosed directly to the water before coagulation and sedimentation. Granular activated carbon may be used as a filter medium replacing sand in existing filters or alternatively in a post-filtration adsorption stage.

6.7.4 Nitrate removal

Nitrate removal is usually achieved by ion-exchange. Water is passed through a column of synthetic resin beads that remove anions including nitrate and exchange them for equivalent amounts of chloride. When the capacity for exchange is exhausted, the resin is regenerated by backwashing with a concentrated solution of sodium chloride. This restores the resin to its initial chloride form. The bed is then rinsed with clean water and returned to service. The waste solution and rinse waters, containing high concentrations of sodium chloride, as well as nitrate, are collected for disposal.

Conventional anion exchange resins have a higher affinity for sulphate than for nitrate. This means that they preferentially remove sulphate and reduce the capacity for nitrate, leading in turn to higher running costs (for regenerant) and greater volumes of waste for disposal. As a result, nitrate-selective resins, which give better uptake of nitrate in the presence of sulphate and reduce process costs, are preferred.

Nitrate-selective resins also add less chloride to the treated water because of the lower sulphate removal; this is desirable since high chloride concentrations and chloride-to-bicarbonate ratios are associated with increased corrosion of certain metals. A sodium bicarbonate rinse can be used after regeneration with sodium chloride to convert the resin in the lower part of the bed to the bicarbonate form and reduce the chloride-to-bicarbonate ratio during the early part of the run.

An ion-exchange plant consists of two or more reactors operated in parallel. Run lengths of up to 24 hours can be achieved before regeneration is necessary. Regeneration consumes up to 2 percent of the volume of treated water and takes about two hours. Performance is affected by the choice of resin, the concentrations of nitrate and sulphate in the raw water, and the volume and concentration of sodium chloride solution used for regeneration. Operation of an ion-exchange plant is normally fully automatic.

Even when using nitrate-selective resins the concentrations of nitrate, sulphate, bicarbonate and chloride vary during a run. These variations can be balanced out by operating two or more beds out of phase and blending the products or by installing large mixing tanks prior to distribution.

Surface waters may require pre-treatment by coagulation to remove organic colour and suspended solids, which would foul the resin.

Nitrate can also be removed by some membrane processes and by biological denitrification. Membrane processes are described in Section 6.8. In biological denitrification, nitrate is converted to nitrogen by de-nitrifying bacteria which, in the absence of dissolved oxygen, use the nitrate as an oxygen source. Biological denitrification occurs naturally in some confined aquifers but is not appropriate for the treatment of small water supplies because of the complexity of the process and the relatively high capital cost.