

2.5 Physical and chemical properties

2.5.1 pH value

The pH value of water is a measure of acidity or alkalinity. Pure water is very slightly ionised into positively charged hydrogen ions (H^+) and negatively charged hydroxide ions (OH^-). Water is neutral when the numbers of hydrogen ions and hydroxide ions are equal. When the concentration of hydrogen ions exceeds that of hydroxide ions, the water is acidic and has a pH value less than 7. Conversely, when the concentration of hydroxide ions exceeds that of hydrogen ions, the water is alkaline and has a pH value greater than 7. The pH scale is logarithmic, therefore a change in pH value of one unit represents a tenfold change in the concentrations of hydrogen and hydroxide ions.

Acidity in raw waters can result from the dissolution of carbon dioxide to produce weak carbonic acid. Groundwaters and surface waters may also contain organic acids produced during the decomposition of vegetation. A surface water derived from a peaty moorland catchment may have a pH value as low as 4. Alkaline waters result almost entirely from the dissolution of the bicarbonate, carbonate and hydroxide salts of calcium, magnesium, sodium and potassium. Soft acidic waters can cause corrosion of pipework and the dissolution of metals such as copper, zinc and lead. Hard, alkaline waters can cause problems associated with scale formation. Some hard waters may also be plumbosolvent.

The UK drinking water quality regulations include pH as an indicator parameter and specify a minimum pH of 6.5 and a maximum pH of 10.0. In water treatment, the pH value can be changed by aeration, alkali or acid dosing or contact with alkaline material in contact beds.

2.5.2 Hardness

Water hardness is caused by dissolved salts of calcium and magnesium. Total hardness consists of temporary and permanent hardness. Temporary hardness is caused almost entirely by the carbonates and bicarbonates of calcium and magnesium. Temporary hardness is precipitated by evaporation and boiling. Permanent hardness is caused almost entirely by the sulphates and chlorides of calcium and magnesium. Permanent hardness is not precipitated by boiling.

The hardness of waters, expressed in mg/l CaCO₃ (calcium carbonate), can be classified as shown below:

Water	Hardness (mg/l CaCO ₃)
soft	up to 50
moderately soft	50 – 100
slightly hard	100 – 150
moderately hard	150 – 200
hard	200 – 300
very hard	over 300

The drinking water Directive and the UK drinking water quality regulations do not specify standards for hardness, calcium or magnesium. Water softening may be applied at water treatment works¹³. This can be achieved by lime-soda softening – the addition of lime (Ca(OH)₂) and sodium carbonate (Na₂CO₃) to the water which causes the hardness compounds to precipitate. An alternative method, common in domestic water softeners, is ion-exchange (base exchange), whereby the calcium and magnesium ions in the water are replaced by sodium ions. Where water is softened by base exchange softening it is important to provide an unsoftened outlet for potable purposes. Installation of a softener just before the hot water tank or boiler is a more economical method for preventing precipitation of hardness salts (limescale) than softening the whole supply.

¹³ The UK Department of Health has stated that “in view of the consistency of the [epidemiological] evidence [of a weak inverse association between natural water hardness and cardiovascular disease mortality], it remains prudent not to undertake softening of drinking water supplies ... it appears sensible to avoid regular consumption of softened water where there is an alternative”.

2.5.3 Colour

Water can be coloured by humic and fulvic materials leaching from peat or other decaying vegetation and by naturally occurring salts of iron or manganese. Surface waters derived from peaty moorland catchments may be strongly coloured. The characteristic brown colour of these waters is variable and often shows a strong seasonal effect, with concentrations being greatest in late autumn and winter. Waters derived from lowland rivers can similarly show a seasonal increase in colour following autumn leaf fall.

A water may appear coloured because of material in suspension and true colour can only be determined after filtration. Colour is expressed in mg/l on the platinum-cobalt (Pt-Co) scale, which is equivalent to measurements expressed in Hazen units ($^{\circ}\text{H}$). The removal of colour from water is necessary not only for aesthetic reasons but also because chlorination of highly coloured waters can give rise to high concentrations of trihalomethanes (see Section 2.4.6). High colour also reduces the efficiency of disinfection by UV irradiation, chlorination and ozonation. Colour will also cause fouling of reverse osmosis membranes.

The drinking water Directive includes colour as an indicator parameter without a numeric standard but with the requirement “Acceptable to consumers and no abnormal change”. The UK water quality regulations specify a standard of 20 mg/l Pt-Co.

Colour removal at a water treatment works is usually achieved by coagulation followed by sedimentation or flotation and filtration. Filtration techniques may be applied to small supplies but the efficiency of colour removal is usually relatively poor.

2.5.4 Turbidity

Turbidity is caused principally by inorganic matter in suspension including mineral sediments and oxides of iron or manganese but organic matter including algae can also cause significant turbidity. Most surface waters show particularly high turbidity following periods of heavy rainfall. Groundwaters generally show low to very low turbidity and variations, following heavy rainfall for example, may indicate rapid recharge bringing in contaminants from the surface.

Turbidity measurement gives a quantitative indication of the clarity of a water and analysis is carried out using a nephelometer. Nephelometers measure the intensity of light scattered in one particular direction, usually perpendicular to the incident light and are relatively unaffected by dissolved colour. Nephelometers are calibrated against turbidity standards prepared from a suspension of formazin and the standard unit of turbidity is the nephelometric turbidity unit or NTU.

Turbidity is removed for aesthetic reasons and because high turbidity can impair the efficiency of disinfection. The drinking water Directive includes turbidity as an indicator parameter without a numeric standard but with the requirement “Acceptable to consumers and no abnormal change”. It also states that for treated surface waters the value should not exceed 1 NTU.

The UK water quality regulations specify a standard of 4 NTU at consumers’ taps with an indicator parameter value of 1 NTU in water leaving treatment works.

Rapid sand filtration or microstraining can remove coarse turbidity and some species of algae. Fine turbidity and many species of algae that may penetrate rapid filters can be removed by slow sand filtration or by coagulation followed by sedimentation or flotation and filtration. A variety of filtration techniques can be successfully applied to small supplies.

2.5.5 Taste and odour

Sources of taste and odour in water include decaying vegetation, algae, moulds and actinomycetes. Taste and odour are usually associated with the presence of specific organic compounds released by the source agent which give rise to ‘earthy’ or ‘musty’ taste or odour. Chlorine and the by-products of chlorination can also cause complaints of taste or odour. Relatively high concentrations of iron, manganese and some other metals can impart an unpleasant metallic taste.

The drinking water Directive includes taste and odour as indicator parameters without numeric standards but with the requirement “Acceptable to consumers and no abnormal change”. The intensity of odour and taste is expressed as Dilution Number – the dilution of the sample with odour or taste free water at which the odour or taste is undetectable. The UK water quality regulations specify standards for both odour and taste of 3 dilution number at 25 °C.

Taste and odour are removed principally for aesthetic reasons. Taste and odour can be reduced or removed by aeration, ozonation or adsorption on activated carbon or, where chlorination is the source of taste or odour, by control of the disinfection process.