

**CAI 334 IRRIGATION WATER QUALITY AND WASTE WATER MANAGEMENT
UNIT I NOTES**



The physical and chemical properties of water**pH value**

The pH value of water is a measure of its 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 or hydroxide ions.

Acidity in raw water can result from the dissolution of carbon dioxide to produce weak carbonic acid. Groundwater and surface water may also contain organic acids produced during the decomposition of vegetation. 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, for instance from limestone aquifers. Soft acidic waters can cause corrosion of pipework and the dissolution of metals such as copper, zinc and lead. Hard alkaline waters can cause scale formation and some hard waters may also be plumbo solvent.

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 $CaCO_3$ (calcium carbonate), can be classified as shown below:

	Water Hardness (mg/l $CaCO_3$)
Soft	up to 50
Slightly hard	100 -150
Moderately hard	150 – 200

Hard	200 – 300
Very hard	More than 300

Table 1: Water Hardness guide

. Softening can be achieved by lime-soda softening, where the addition of lime (Ca(OH)_2) and sodium carbonate (Na_2CO_3) to the water 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.

Water hardness is a measure of the concentration of dissolved minerals, primarily calcium and magnesium ions, in water. These minerals are often present in groundwater and can affect various aspects of irrigation:

1. **Soil Salinity:** Hard water can contribute to soil salinity buildup over time. When hard water is used for irrigation, the calcium and magnesium ions can accumulate in the soil, displacing other cations like sodium and potassium. This can lead to increased soil salinity, negatively impacting soil structure, water infiltration, and plant root development.
2. **Clogging of Irrigation Equipment:** Hard water can cause scaling or mineral deposits to form on the surfaces of irrigation equipment, such as pipes, valves, and emitters. This scaling reduces the efficiency of irrigation systems by restricting water flow and distribution. It can also increase maintenance requirements and the need for cleaning or replacement of affected components.
3. **Impact on Plant Health:** High levels of water hardness can affect plant health and growth. Calcium and magnesium ions from hard water can interfere with nutrient uptake by plant roots and may lead to nutrient imbalances. Additionally, excessive salts in the soil due to hard water irrigation can cause osmotic stress on plants, reducing their ability to absorb water and nutrients.
4. **pH Imbalance:** Water hardness can influence the pH of irrigation water and soil. Calcium and magnesium ions in hard water can react with bicarbonate ions to form insoluble calcium carbonate and magnesium hydroxide, raising the pH of the water. This can affect nutrient availability and soil pH, potentially leading to nutrient deficiencies or toxicities in plants.

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 water derived from peaty moorland catchments may be strongly coloured. The characteristic brown colour of such water is variable and often shows a strong seasonal effect, with concentrations being

greatest in late autumn and winter. Water derived from lowland rivers can similarly show a seasonal increase in colour following autumn leaf fall.

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. High colour also reduces the efficiency of disinfection by UV irradiation, chlorination and ozonation and 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”.

Turbidity

Turbidity is caused principally by inorganic matter in suspension including mineral sediments (e.g. from chalk) 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, whilst groundwater generally shows low to very low turbidity. However, 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 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. The standard unit of turbidity is the nephelometric turbidity unit or NTU.

Turbidity is removed because high turbidity can impair the efficiency of disinfection and for aesthetic reasons. The UK water quality regulations specify a standard of 4NTU at consumers' taps with an indicator parameter value of 1NTU in water leaving a treatment works. A variety of filtration techniques can be successfully applied to small supplies, and cartridge filters are the most widely employed.

The effect of turbidity on irrigation can be significant and depends on several factors:

1. **Soil Clogging:** Turbid water used for irrigation can contain suspended particles that may settle and accumulate in soil pores, leading to soil clogging. This can decrease soil permeability and affect water infiltration, potentially reducing the effectiveness of irrigation and limiting root growth.
2. **Water Quality** Turbid water may contain contaminants such as silt, clay, organic matter, or pathogens. These contaminants can negatively impact soil fertility, plant health, and crop

yields. Excessive turbidity can also reduce the penetration of sunlight into the water column, affecting aquatic plant growth and ecosystem health in irrigation reservoirs or ponds.

3. **Filter Clogging** Irrigation systems, such as drip irrigation or sprinklers, may be prone to clogging when using turbid water. Suspended particles in the water can accumulate and block the openings of irrigation nozzles or filters, reducing water flow rates and system efficiency. This can result in uneven water distribution and decreased irrigation uniformity, affecting crop growth and yield.
4. **Sedimentation** Turbid water can deposit sediment in irrigation canals, ditches, or reservoirs over time. This sedimentation can reduce water storage capacity, increase maintenance costs, and require additional resources for dredging or sediment removal to maintain irrigation infrastructure.

Taste and odour

Sources of taste and odour in source 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. Domestic plumbing materials and arrangements and in some circumstances water mains may also impart a noticeable taste or odour.

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 a Dilution Number, which is the dilution of the sample with odour or taste free water at which the odour or taste is undetectable.

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.

Radioactivity

All environmental water contains traces of naturally occurring radionuclides, the concentrations of which depend on the origin of the water. The natural radionuclides of most relevance to drinking water supplies are radon (Rn) and uranium (U). Radon is volatile and as a result it can be released from water as a gas. This is of concern if the release occurs within a confined space with insufficient ventilation. Radon and uranium are only found in significant concentrations in groundwater in certain parts of the UK, depending on the type of geology from which the groundwater originates. The concentration of radioactive elements in water is expressed in terms of their activity, in Becquerels per litre (Bq/l).

CAI 334 IRRIGATION WATER QUALITY AND WASTE WATER MANAGEMENT

Treatment for radon cannot include point-of-use systems fitted to the tap because, being volatile, it is released into the atmosphere whenever water is used. Under-sink treatment using an activated carbon filter is also inadvisable because the filter would become radioactive. Radon removal treatment therefore has to be installed before entry of water into a building and aeration is the preferred treatment technique although other methods are feasible. Uranium removal is best achieved by point-of-use systems.