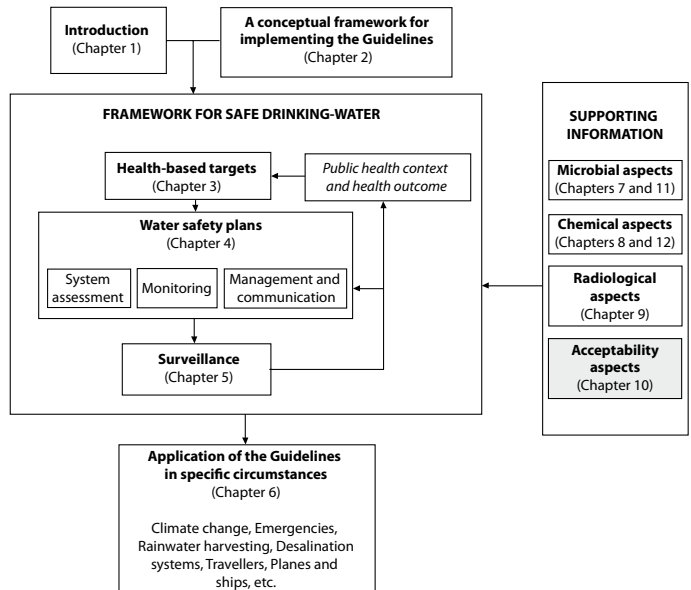


Acceptability aspects: Taste, odour and appearance

The provision of drinking-water that is not only safe but also acceptable in appearance, taste and odour is of high priority. Water that is aesthetically unacceptable will undermine the confidence of consumers, will lead to complaints and, more importantly, could lead to the use of water from sources that are less safe.

To a large extent, consumers have no means of judging the safety of their drinking-water themselves, but their attitude towards their drinking-water supply and their drinking-water suppliers will be affected to a considerable extent by the aspects of water quality that they are able to perceive with their own senses. It is natural for consumers to regard with suspicion water that appears dirty or discoloured or that has an unpleasant taste or smell, even though these characteristics may not in themselves be of direct consequence to health.



The appearance, taste and odour of drinking-water should be acceptable to the consumer. Water that is aesthetically unacceptable can lead to the use of water from sources that are aesthetically more acceptable, but potentially less safe.

Some substances of health concern have effects on the taste, odour or appearance of drinking-water that would normally lead to rejection of the water at concentrations significantly lower than those of concern for health.

The concentration at which constituents are objectionable to consumers is variable and dependent on individual and local factors, including the quality of the water to which the community is accustomed and a variety of social, environmental and cultural considerations. Guideline values have not been established for constituents influencing water quality

Guideline values have not been established for constituents influencing water quality that have no direct link to adverse health impacts.

that have no direct link to adverse health impacts. However, guideline values have been established for some substances that may cause taste or odour in drinking-water at much lower concentrations than the guideline value because there is such a wide range in the ability of consumers to detect them by taste or odour. In the summaries in this chapter and the fact sheets in [chapter 12](#), reference is made to levels likely to give rise to complaints from consumers. These are not precise numbers, and tastes or odours may be detectable by consumers at lower or higher levels, depending on individual and local circumstances.

It is important to consider whether existing or proposed water treatment and distribution practices can affect the acceptability of drinking-water and to manage change and operations to minimize the risk of problems for acceptability as well as health. For example, chloramination that is not properly managed can lead to the formation of trichloramines, which can cause unacceptable taste and odour. Other problems may be indirect, such as the disturbance of internal pipe deposits and biofilms when the flow is disturbed or changed in distribution systems.

It is not normally appropriate to directly regulate or monitor substances of health concern whose effects on the acceptability of water would normally lead to rejection of the water at concentrations significantly lower than those of concern for health; rather, these substances may be addressed through a general requirement that water be acceptable to the majority of consumers. For such substances, a formal guideline value is not usually derived, but a health-based value is derived in order to assist in judging the response that is needed when problems are encountered and in some cases to provide reassurance to health authorities and consumers with regard to possible health risks. In the fact sheets in [chapter 12](#), this is explained, and information on acceptability is described. In the tables of guideline values (see [chapter 8](#) and [Annex 3](#)), for those chemicals for which health-based guideline values were derived, the guideline value is designated with a “C”, with a footnote explaining that while the substance is of health significance, water would normally be rejected by consumers at concentrations well below the health-based guideline value. Monitoring of such substances should be undertaken in response to consumer complaints.

Taste and odour can originate from natural inorganic and organic chemical contaminants and biological sources or processes (e.g. aquatic microorganisms), from contamination by synthetic chemicals, from corrosion or as a result of problems with water treatment (e.g. chlorination). Taste and odour may also develop during storage and distribution as a result of microbial activity.

Taste and odour in drinking-water may be indicative of some form of pollution or of a malfunction during water treatment or distribution. It may therefore be an indication of the presence of potentially harmful substances. The cause should be investigated and the appropriate health authorities should be consulted, particularly if there is a sudden or substantial change.

Colour, cloudiness, particulate matter and visible organisms may also be noticed by consumers and may create concerns about the quality and acceptability of a drinking-water supply.

10.1 Biologically derived contaminants

There are a number of diverse organisms that often have no public health significance but which are undesirable because they produce taste and odour. As well as affecting the acceptability of the water, they indicate that water treatment and/or the state of maintenance and repair of the distribution system are insufficient.

Actinomycetes and fungi

Actinomycetes and fungi can be abundant in surface water sources, including reservoirs, and they can also grow on unsuitable materials in the water supply distribution systems, such as rubber. They can produce geosmin, 2-methyl isoborneol and other substances, resulting in objectionable tastes and odours in the drinking-water.

Cyanobacteria and algae

Blooms of cyanobacteria and other algae in reservoirs and in river waters may impede coagulation and filtration, causing coloration and turbidity of water after filtration. They can also produce geosmin, 2-methyl isoborneol and other chemicals, which have taste thresholds in drinking-water of a few nanograms per litre. Some other cyanobacterial products—cyanotoxins—are also of direct health significance (see [section 8.5.1](#)), but the production by cyanobacteria of chemicals with effects on taste does not seem to be linked to the production of cyanotoxins.

Invertebrate animal life¹

Invertebrate animals are naturally present in many water resources used as sources for the supply of drinking-water and often infest shallow, open wells. Small numbers of invertebrates may also pass through water treatment works where the barriers to particulate matter are not completely effective and colonize filters or the distribution system. Their motility may enable them and their larvae to penetrate filters at the treatment works and vents on storage reservoirs.

The types of invertebrates concerned can be considered, for control purposes, as belonging to two groups. First, there are free-swimming organisms in the water itself or on water surfaces, such as the crustaceans *Gammarus pulex* (freshwater shrimp), *Crangonyx pseudogracilis*, *Cyclops* spp. and *Chydorus sphaericus*. Second, there are other invertebrates that either move along surfaces or are anchored to them (e.g. water

¹ The section was drawn largely from chapter 6 of the supporting document *Safe piped water* ([Annex 1](#)).

louse [*Asellus aquaticus*], snails, zebra mussel [*Dreissena polymorpha*], other bivalve molluscs and the bryozoan *Plumatella* sp.) or inhabit slimes (e.g. *Nais* spp., nematodes and the larvae of chironomids). In warm weather, slow sand filters can sometimes discharge the larvae of gnats (*Chironomus* and *Culex* spp.) into the water. In certain circumstances, these can reproduce parthenogenetically (i.e. asexual reproduction), which can exacerbate the problem in service reservoirs and distribution.

Many of these invertebrates can survive, deriving food from bacteria, algae and protozoa in the water or present on slimes on pipe and tank surfaces. Few water distribution systems are completely free of animals at all times. However, the density and composition of invertebrate populations vary widely, from heavy infestations, including readily visible species that are objectionable to consumers, to sparse occurrences of microscopic species.

The presence of invertebrates has largely been regarded by piped drinking-water suppliers in temperate regions as an acceptability problem, either directly or through their association with discoloured water. Large invertebrate populations also indicate high levels of organic material that may give rise to other water quality issues, such as microbial growth. In tropical and subtropical countries, in contrast, there are species of aquatic invertebrates that act as secondary hosts for parasites. For example, the small crustacean *Cyclops* is the intermediate host of the guinea worm (*Dracunculus medinensis*) (see [sections 7.1.1](#) and [11.4](#)). However, there is no evidence that guinea worm transmission occurs from piped drinking-water supplies. The presence of invertebrates in drinking-water, especially if visible, raises consumer concern about the quality of the drinking-water supply and should be controlled.

Penetration of waterworks and mains is more likely to be a problem when high-rate filtration processes are used, but problems can arise even at well-run treatment works. Regular cleaning of water mains by flushing and/or swabbing will usually control infestation.

Treatment of invertebrate infestations in piped distribution systems is discussed in detail in [chapter 6](#) of the supporting document *Safe piped water* ([Annex 1](#)).

Iron bacteria

In waters containing ferrous and manganous salts, oxidation by iron bacteria (or by exposure to air) may cause rust-coloured deposits on the walls of tanks, pipes and channels and carry-over of deposits into the water.

10.2 Chemically derived contaminants

Aluminium

Naturally occurring aluminium as well as aluminium salts used as coagulants in drinking-water treatment are the primary sources of aluminium in drinking-water. The presence of aluminium at concentrations in excess of 0.1–0.2 mg/l often leads to consumer complaints as a result of deposition of aluminium hydroxide floc and the exacerbation of discoloration of water by iron. It is therefore important to optimize treatment processes in order to minimize any residual aluminium entering the distribution system. Under good operating conditions, aluminium concentrations of less

than 0.1 mg/l are achievable in many circumstances. Available evidence does not support the derivation of a health-based guideline value for aluminium in drinking-water (see [sections 8.5.4](#) and [12.1](#)).

Ammonia

The threshold odour concentration of ammonia at alkaline pH is approximately 1.5 mg/l, and a taste threshold of 35 mg/l has been proposed for the ammonium cation. Ammonia is not of direct relevance to health at these levels, and no health-based guideline value has been proposed (see [sections 8.5.3](#) and [12.1](#)). However, ammonia does react with chlorine to reduce free chlorine and to form chloramines.

Chloramines

Chloramines, such as monochloramine, dichloramine and trichloramine (nitrogen trichloride), are generated from the reaction of chlorine with ammonia. Among chloramines, monochloramine is the only useful chlorine disinfectant, and chloramination systems are operated to minimize the formation of dichloramine and trichloramine. Higher chloramines, particularly trichloramine, are likely to give rise to taste and odour complaints, except at very low concentrations.

For monochloramine, no odour or taste was detected at concentrations between 0.5 and 1.5 mg/l. However, slight organoleptic effects within this range and odour and taste thresholds of 0.65 and 0.48 mg/l have been reported. For dichloramine, the organoleptic effects between 0.1 and 0.5 mg/l were found to be “slight” and “acceptable”. Odour and taste thresholds of 0.15 and 0.13 mg/l were reported, respectively. An odour threshold of 0.02 mg/l has been reported for trichloramine, and it has been described as “geranium”.

A guideline value for monochloramine has been established (see [sections 8.5.4](#) and [12.1](#)).

Chloride

High concentrations of chloride give a salty taste to water and beverages. Taste thresholds for the chloride anion depend on the associated cation and are in the range of 200–300 mg/l for sodium, potassium and calcium chloride. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste, but some consumers may become accustomed to low levels of chloride-induced taste. No health-based guideline value is proposed for chloride in drinking-water (see [sections 8.5.1](#) and [12.1](#)).

Chlorine

Most individuals are able to taste or smell chlorine in drinking-water at concentrations well below 5 mg/l, and some at levels as low as 0.3 mg/l. The taste threshold for chlorine is below the health-based guideline value of 5 mg/l (see [sections 8.5.4](#) and [12.1](#)).

Chlorobenzenes

Taste and odour thresholds of 10–20 µg/l and odour thresholds ranging from 40 to 120 µg/l have been reported for monochlorobenzene. A health-based guideline value

has not been derived for monochlorobenzene (see [sections 8.5.2](#) and [12.1](#)), although the health-based value that could be derived far exceeds the lowest reported taste and odour threshold in water.

Odour thresholds of 2–10 and 0.3–30 µg/l have been reported for 1,2- and 1,4-dichlorobenzene, respectively. Taste thresholds of 1 and 6 µg/l have been reported for 1,2- and 1,4-dichlorobenzene, respectively. The health-based guideline values of 1 mg/l derived for 1,2-dichlorobenzene and of 0.3 mg/l for 1,4-dichlorobenzene (see [sections 8.5.2](#) and [12.1](#)) far exceed the lowest reported taste and odour thresholds for these compounds.

Odour thresholds of 10, 5–30 and 50 µg/l have been reported for 1,2,3-, 1,2,4- and 1,3,5-trichlorobenzene, respectively. A taste and odour threshold concentration of 30 µg/l has been reported for 1,2,4-trichlorobenzene. A health-based guideline value was not derived for trichlorobenzenes, although the health-based value that could be derived (see [sections 8.5.2](#) and [12.1](#)) exceeds the lowest reported odour threshold in water of 5 µg/l.

Chlorophenols

Chlorophenols generally have very low taste and odour thresholds. The taste thresholds in water for 2-chlorophenol, 2,4-dichlorophenol and 2,4,6-trichlorophenol are 0.1, 0.3 and 2 µg/l, respectively. Odour thresholds are 10, 40 and 300 µg/l, respectively. If water containing 2,4,6-trichlorophenol is free from taste, it is unlikely to present a significant risk to health (see [sections 8.5.4](#) and [12.1](#)). Microorganisms in distribution systems may sometimes methylate chlorophenols to produce chlorinated anisoles, for which the odour threshold is considerably lower.

Colour

Drinking-water should ideally have no visible colour. Colour in drinking-water is usually due to the presence of coloured organic matter (primarily humic and fulvic acids) associated with the humus fraction of soil. Colour is also strongly influenced by the presence of iron and other metals, either as natural impurities or as corrosion products. It may also result from the contamination of the water source with industrial effluents and may be the first indication of a hazardous situation. The source of colour in a drinking-water supply should be investigated, particularly if a substantial change has taken place.

Most people can detect colour above 15 true colour units (TCU) in a glass of water. Levels of colour below 15 TCU are often acceptable to consumers. High colour from natural organic carbon (e.g. humics) could also indicate a high propensity to produce by-products from disinfection processes. No health-based guideline value is proposed for colour in drinking-water.

Copper

Copper in a drinking-water supply usually arises from the corrosive action of water leaching copper from copper pipes in buildings. High levels of dissolved oxygen have been shown to accelerate copper corrosion in some cases. Concentrations can vary significantly with the period of time the water has been standing in contact with the pipes; for example, first-draw water would be expected to have a higher copper con-

centration than a fully flushed sample. High concentrations can interfere with the intended domestic uses of the water. Staining of sanitary ware and laundry may occur at copper concentrations above 1 mg/l. At levels above 5 mg/l, copper also imparts a colour and an undesirable bitter taste to water. Although copper can give rise to taste, it should be acceptable at the health-based guideline value of 2 mg/l (see [sections 8.5.4, 12.1](#) and [A5.3](#) in [Annex 5](#)).

Dissolved oxygen

The dissolved oxygen content of water is influenced by the source, raw water temperature, treatment and chemical or biological processes taking place in the distribution system. Depletion of dissolved oxygen in water supplies can encourage the microbial reduction of nitrate to nitrite and sulfate to sulfide. It can also cause an increase in the concentration of ferrous iron in solution, with subsequent discoloration at the tap when the water is aerated. No health-based guideline value is recommended. However, very high levels of dissolved oxygen may exacerbate corrosion of metal pipes.

Ethylbenzene

Ethylbenzene has an aromatic odour; the reported odour threshold in water ranges from 2 to 130 µg/l. The lowest reported odour threshold is 100-fold lower than the health-based guideline value of 0.3 mg/l (see [sections 8.5.2](#) and [12.1](#)). The taste threshold ranges from 72 to 200 µg/l.

Hardness

Hardness caused by calcium and magnesium is usually indicated by precipitation of soap scum and the need for excess use of soap to achieve cleaning. Consumers are likely to notice changes in hardness. Public acceptability of the degree of hardness of water may vary considerably from one community to another. The taste threshold for the calcium ion is in the range of 100–300 mg/l, depending on the associated anion, and the taste threshold for magnesium is probably lower than that for calcium. In some instances, consumers tolerate water hardness in excess of 500 mg/l.

Depending on the interaction of other factors, such as pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the treatment works, distribution system and pipework and tanks within buildings. It will also result in high soap consumption and subsequent “scum” formation. On heating, hard waters form deposits of calcium carbonate scale. Soft water, but not necessarily cation exchange softened water, with a hardness of less than 100 mg/l, may, in contrast, have a low buffering capacity and so be more corrosive for water pipes.

No health-based guideline value is proposed for hardness in drinking-water (see the supporting document *Calcium and magnesium in drinking-water*; [Annex 1](#)).

Hydrogen sulfide

The taste and odour thresholds of hydrogen sulfide in water are estimated to be between 0.05 and 0.1 mg/l. The “rotten eggs” odour of hydrogen sulfide is particularly

noticeable in some groundwaters and in stagnant drinking-water in the distribution system, as a result of oxygen depletion and the subsequent reduction of sulfate by bacterial activity.

Sulfide is oxidized rapidly to sulfate in well-aerated or chlorinated water, and hydrogen sulfide levels in oxygenated water supplies are normally very low. The presence of hydrogen sulfide in drinking-water can be easily detected by the consumer and requires immediate corrective action. It is unlikely that a person could consume a harmful dose of hydrogen sulfide from drinking-water; hence, a health-based guideline value has not been derived for this compound (see [sections 8.5.1](#) and [12.1](#)).

Iron

Anaerobic groundwater may contain ferrous iron at concentrations up to several milligrams per litre without discoloration or turbidity in the water when directly pumped from a well. On exposure to the atmosphere, however, the ferrous iron oxidizes to ferric iron, giving an objectionable reddish-brown colour to the water.

Iron also promotes the growth of “iron bacteria”, which derive their energy from the oxidation of ferrous iron to ferric iron and in the process deposit a slimy coating on the piping. At levels above 0.3 mg/l, iron stains laundry and plumbing fixtures. There is usually no noticeable taste at iron concentrations below 0.3 mg/l, although turbidity and colour may develop. No health-based guideline value is proposed for iron (see [sections 8.5.4](#) and [12.1](#)).

Manganese

At levels exceeding 0.1 mg/l, manganese in water supplies may cause an undesirable taste in beverages and stains sanitary ware and laundry. The presence of manganese in drinking-water, like that of iron, may lead to the accumulation of deposits in the distribution system. Concentrations below 0.1 mg/l are usually acceptable to consumers. Even at a concentration of 0.2 mg/l, manganese will often form a coating on pipes, which may slough off as a black precipitate. The health-based value of 0.4 mg/l for manganese is higher than this acceptability threshold of 0.1 mg/l (see [sections 8.5.1](#) and [12.1](#)). However, under some conditions, manganese can be at concentrations above 0.1 mg/L and may remain in solution for a longer period compared with its usual solubility in most drinking-water.

Petroleum oils

Petroleum oils can give rise to the presence of a number of low molecular weight hydrocarbons that have low odour thresholds in drinking-water. Benzene, toluene, ethylbenzene and xylenes (BTEX) are considered individually in this section, as health-based guideline values have been derived for these chemicals. However, a number of other hydrocarbons, particularly alkylbenzenes such as trimethylbenzene, may give rise to a very unpleasant “diesel-like” odour at concentrations of a few micrograms per litre. There is experience indicating that the taste threshold of a mixture of low molecular weight aromatic hydrocarbons is lower than the threshold of individual substances. Diesel is a particularly rich source of such substances.

pH and corrosion

Although pH usually has no direct impact on consumers, it is one of the most important operational water quality parameters. Careful attention to pH control is ne-

cessary at all stages of water treatment to ensure satisfactory water clarification and disinfection (see the supporting document *Safe piped water*; [Annex 1](#)). For effective disinfection with chlorine, the pH should preferably be less than 8; however, lower-pH water (approximately pH 7 or less) is more likely to be corrosive. The pH of the water entering the distribution system must be controlled to minimize the corrosion of water mains and pipes in household water systems. Alkalinity and calcium management also contribute to the stability of water and control its aggressiveness to pipes and appliances. Failure to minimize corrosion can result in the contamination of drinking-water and in adverse effects on its taste and appearance. The optimum pH required will vary in different supplies according to the composition of the water and the nature of the construction materials used in the distribution system, but it is usually in the range 6.5–8.5 (see [section 8.4.3](#)). Extreme values of pH can result from accidental spills, treatment breakdowns and insufficiently cured cement mortar pipe linings or cement mortar linings applied when the alkalinity of the water is low. No health-based guideline value has been proposed for pH (see [section 12.1](#)).

Sodium

The taste threshold concentration of sodium in water depends on the associated anion and the temperature of the solution. At room temperature, the average taste threshold for sodium is about 200 mg/l. No health-based guideline value has been derived (see [sections 8.5.1](#) and [12.1](#)), as the contribution from drinking-water to daily intake is small.

Styrene

Styrene has a sweet/sickly odour, and reported odour thresholds for styrene in water range from 0.004 to 2.6 mg/l, depending on temperature. Styrene may therefore be detected in water at concentrations below its health-based guideline value of 0.02 mg/l (see [sections 8.5.2](#) and [12.1](#)).

Sulfate

The presence of sulfate in drinking-water can cause noticeable taste, and very high levels might cause a laxative effect in unaccustomed consumers. Taste impairment varies with the nature of the associated cation; taste thresholds have been found to range from 250 mg/l for sodium sulfate to 1000 mg/l for calcium sulfate. It is generally considered that taste impairment is minimal at levels below 250 mg/l. No health-based guideline value has been derived for sulfate (see [sections 8.5.1](#) and [12.1](#)).

Synthetic detergents

In many countries, persistent types of anionic detergent have been replaced by others that are more easily biodegraded, and hence the levels found in water sources have decreased substantially. The concentration of detergents in drinking-water should not be allowed to reach levels giving rise to either foaming or taste problems. The presence of any detergent may indicate contamination of source water with sewage or ingress of detergent solution into the distribution system, as a result of back-flow, for example.

Toluene

Toluene has a sweet, pungent, benzene-like odour. The reported taste threshold ranges from 0.04 to 0.12 mg/l. The reported odour threshold for toluene in water ranges from 0.024 to 0.17 mg/l. Toluene may therefore affect the acceptability of water at concentrations below its health-based guideline value of 0.7 mg/l (see [sections 8.5.2](#) and [12.1](#)).

Total dissolved solids

The palatability of water with a total dissolved solids (TDS) level of less than about 600 mg/l is generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l. The presence of high levels of TDS may also be objectionable to consumers, owing to excessive scaling in water pipes, heaters, boilers and household appliances. No health-based guideline value for TDS has been proposed (see [sections 8.5.1](#) and [12.1](#)).

Turbidity

Turbidity, typically expressed as nephelometric turbidity units (NTU), describes the cloudiness of water caused by suspended particles (e.g. clay and silts), chemical precipitates (e.g. manganese and iron), organic particles (e.g. plant debris) and organisms. Turbidity can be caused by poor source water quality, poor treatment and, within distribution systems, disturbance of sediments and biofilms or the ingress of dirty water through main breaks and other faults. At high levels, turbidity can lead to staining of materials, fittings and clothes exposed during washing, in addition to interfering with the effectiveness of treatment processes (see [Tables 7.7](#) and [7.8](#) in [chapter 7](#)).

Increasing turbidity reduces the clarity of water to transmitted light. Below 4 NTU, turbidity can be detected only using instruments, but at 4 NTU and above, a milky-white, muddy, red-brown or black suspension can be visible. Large municipal supplies should consistently produce water with no visible turbidity (and should be able to achieve 0.5 NTU before disinfection at all times and average 0.2 NTU or less). However, small supplies, particularly those where resources are limited, may not be able to achieve such levels.

Visible turbidity reduces the acceptability of drinking-water. Although most particles that contribute to turbidity have no health significance (even though they may indicate the presence of hazardous chemical and microbial contaminants), many consumers associate turbidity with safety and consider turbid water as being unsafe to drink. This response is exacerbated when consumers have been used to receiving high-quality filtered water. If consumers lose confidence in a drinking-water supply, they may drink less water or use lower turbidity alternatives that may not be safe. Any complaints about unexpected turbidity should always be investigated because they could reflect significant faults or breaches in distribution systems.

Further information is available in *Turbidity: information for regulators and operators of water supplies* (see [Annex 1](#)).

Xylenes

Xylene concentrations in the range of 0.3 mg/l produce a detectable taste and odour. The odour threshold for xylene isomers in water has been reported to range from 0.02 to 1.8 mg/l. The lowest odour threshold is well below the health-based guideline value of 0.5 mg/l for xylene (see [sections 8.5.2](#) and [12.1](#)).

Zinc

Zinc imparts an undesirable astringent taste to water at a taste threshold concentration of about 4 mg/l (as zinc sulfate). Water containing zinc at concentrations in excess of 3–5 mg/l may appear opalescent and develop a greasy film on boiling. Although drinking-water seldom contains zinc at concentrations above 0.1 mg/l, levels in tap water can be considerably higher because of the zinc used in older galvanized plumbing materials; this may also be an indicator of elevated cadmium from such older

material. No health-based guideline value has been proposed for zinc in drinking-water (see [sections 8.5.4](#) and [12.1](#)).

10.3 Treatment of taste, odour and appearance problems

In many cases, aesthetic problems will be prevented by optimizing conventional treatment processes such as coagulation, sedimentation and chlorination. However, if specific treatment is deemed necessary, aeration, granular or powdered activated carbon and ozonation are generally effective techniques in removing organic chemicals and some inorganic chemicals, such as hydrogen sulfide, that cause tastes and odours. (see [Annex 5](#)).

Tastes and odours caused by disinfectants are best controlled through careful operation of the disinfection process and pretreatment to remove precursors.

Manganese can be removed by chlorination followed by filtration. Techniques for removing hydrogen sulfide include aeration, granular activated carbon, filtration and oxidation. Ammonia can be removed by biological nitrification. Precipitation softening or cation exchange can reduce hardness. Other taste- and odour-causing inorganic chemicals (e.g. chloride and sulfate) are generally not amenable to treatment (see the supporting document *Chemical safety of drinking-water*; [Annex 1](#)).

10.4 Temperature

Cool water is generally more palatable than warm water, and temperature will have an impact on the acceptability of a number of other inorganic constituents and chemical contaminants that may affect taste. High water temperature enhances the growth of microorganisms and may increase problems related to taste, odour, colour and corrosion.