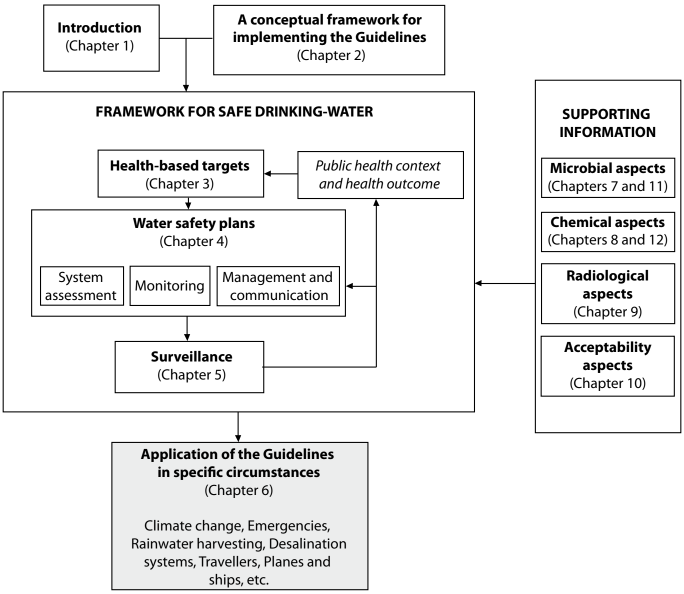
6
Application of the Guidelines in specific circumstances



These Guidelines provide a generally applicable approach to ensuring the safety of drinking-water supplied through piped distribution and community supplies. This chapter describes the application of the Guidelines in some commonly encountered circumstances and specific issues that should be taken into account in each. The sections are not intended to stand alone, and reference is made to more comprehensive supporting documents that provide detailed guidance. In all the specific circumstances described below, the principles enshrined in water safety plans (WSPs) apply. However, the WSP should be tailored to the type of supply in each circumstance; for example, routine chemical and microbiological monitoring of rainwater may not be feasible at a household level, but preventive barriers are both applicable and achievable.

As indicated in chapter 4, WSPs require careful consideration of possible hazards, and forward planning is one of the important requirements in ensuring that both the quantity and quality of water supplies are maintained. One of the significant concerns for the future is climate change, but there remains considerable uncertainty as to its impact on a local or even subregional level. Nevertheless, it is expected that all types of supply will be affected, including the specific circumstances discussed below.

6.1 Climate change, water scarcity and heavy rainfall

Regional or localized droughts and heavy precipitation events and floods have always occurred, but they appear to be increasing in frequency, and greater extremes of climate should be expected. Anticipating and planning for these events, such that sufficient quantities of safe water can be delivered to consumers without disruptions, are not only key responsibilities of water suppliers, but a growing challenge. The effects of these climate extremes on water quality and quantity will be especially acute in areas with growing populations. In such areas, existing water supplies typically are already stressed, and there is little, if any, water supply margin available to them in the event of a major or extended duration weather event. This is especially true in regions with desert-like climates, such as parts of the Mediterranean, the Middle East, Australia and the south-western United States of America.

Over an extended period of time, climate change may foster greater extremes in weather, including more frequent and longer spells with much higher peak temperatures, droughts, greater frequency of heavy precipitation and violent storms. Changes in sea level from melting ice can affect coastal groundwater, causing salination, which may also occur as a result of over-abstraction. With changes in water quantity come changes in water quality: greater or lesser runoff affects the sediment loading, chemical composition, total organic carbon content and microbial quality. These changes require modifications in water storage capacity and water treatment to ensure safe drinking-water. Changes in groundwater levels may also lead to altered mineral composition, and moves to deeper groundwater may tap into aquifers with high mineral content or high levels of specific constituents of concern for health.

To provide for adequate water quantity and quality in the event of these changes and extremes, natural supplies may need to be augmented in some areas, together with use of more climate-resilient technologies and processes. Water treatment systems may need to be upgraded and obtain greater storage capacity to be able to cope with greater microbial, turbidity and chemical loadings. New sources of water may need to be developed, such as recycled wastewater or desalinated brackish water or seawater, and new strategies may need to be implemented, such as aquifer storage and recovery.

6.2 Rainwater harvesting

Rainwater harvesting is widely practised at a household level but is increasingly being used on a larger community scale. Rainwater can provide an important source of drinking-water in some circumstances as well as a useful source of water for blending with other sources to reduce the levels of contaminants of health concern, such as arsenic and fluoride.

The development of formal WSPs at the household level may not always be practical, but promotion of sanitary inspection with simple good practice is important. Well-designed rainwater harvesting systems with clean catchments, covered cisterns and storage tanks, and treatment, as appropriate, supported by good hygiene at point of use, can offer drinking-water with very low health risk.

Rainwater is initially relatively free from impurities, except those picked up by the rain from the atmosphere. However, the quality of rainwater may subsequently deteriorate during harvesting, storage and household use. Wind-blown dirt, leaves, faecal droppings from birds and other animals, insects and litter on the catchment areas, such as roofs and in cisterns, can contaminate rainwater, as can particles from the atmosphere, such as soot from burning materials such as old tyres. Regular cleaning of catchment surfaces and gutters should be undertaken to minimize the accumulation of debris. Wire meshes or inlet filters should be placed over the top of downpipes to prevent leaves and other debris from entering storage containers and cleaned regularly to prevent clogging.

Materials used in the catchment and storage tank should be approved for use in contact with drinking-water and should not leach contaminants or cause taste, odour or discoloration. As rainwater is slightly acidic and very low in dissolved minerals, it can dissolve metals and other impurities from materials of the catchment and storage tank, resulting in unacceptably high concentrations of contaminants in the water. Most solid roof materials are suitable for collecting rainwater, but roofs with bitumen-based coatings are generally not recommended, as they may leach hazardous substances or cause taste problems. Care should be taken to ensure that lead-based paints are not used on roof catchments. Thatched roofs can cause discoloration or deposition of particles in collected water.

Poor hygiene in water storage and abstraction from storage containers or at the point of use can also represent a health concern, but risks can be minimized by good design and practice. Faecal contamination is quite common, particularly in samples collected shortly after rainfall, but can be minimized by good practice. Higher microbial concentrations are generally found in the first flush of rainwater, decreasing as the rain continues; therefore, microbial contamination is less in rainy seasons when catchments are frequently washed with fresh rainwater. A system to divert the contaminated first flow of rainwater from roof surfaces is necessary, and automatic devices that prevent the first flush of runoff from being collected in storage are recommended. If diverters are not available, a detachable downpipe can be used manually to provide the same result.

Storage tanks can present breeding sites for mosquitoes, including species that transmit dengue virus (see section 8.6). Covers discourage mosquito breeding and help to prevent faecal contaminants and sunlight, which will promote algal growth, from reaching the water. Covers should be fitted, and openings need to be protected by mosquito-proof mesh. Cracks in the tank can result in contamination of stored water, whereas water withdrawal using contaminated containers is a potential cause of both faecal and chemical contamination. Storage containers should preferably be fitted with a mechanism such as a tap or outlet pipe that enables hygienic abstraction of water.

Further treatment at the point of consumption may be applied to ensure better quality of drinking-water and reduce health risk. Solar water disinfection and point-of-use chlorination are examples of low-cost disinfection options for the treatment of stored rainwater. These and other household water treatment technologies are discussed in more detail in sections 7.3.2 (microbial) and 8.4.4 (chemical).

6.3 Vended water

Vended water is common in many parts of the world where scarcity of supplies or lack of infrastructure limits access to suitable quantities of safe drinking-water. Although water vending is more common in developing countries, it also occurs in developed countries.

In the context of these Guidelines, water vending implies private vending of drinking-water, but does not include bottled or packaged water (which is considered in section 6.14) or water sold in bottles through vending machines.

Water vending may be undertaken by formal bodies, such as water utilities or registered associations, by contracted suppliers or by informal and independent suppliers. Where formal vending is practised, the water typically comes from treated utility supplies or registered sources and is supplied in tankers or from standpipes and water kiosks. Informal suppliers tend to use a range of sources, including untreated surface water, dug wells and boreholes, and deliver small volumes for domestic use, often in containers loaded onto small carts or tanker trucks.

Both the quality and adequacy of vended supplies can vary significantly, and vended water has been associated with outbreaks of diarrhoeal disease (Hutin, Luby & Paquet, 2003). Water supplied to users should be suitable for drinking and comply with national or regional guidelines and regulatory requirements. The chemical and microbial quality of untreated or private sources of water should be tested to determine their suitability for use and to identify appropriate control measures, including treatment requirements. Surface water and some dug well and borehole waters are not suitable for drinking without treatment; disinfection is the minimum requirement, and filtration is often required when surface water is used.

In many developing countries, consumers purchase water from kiosks and then carry the water home in a variety of containers of varying size. Measures should be taken to protect vended water from contamination during transport as well as storage in the home, including transporting and storing water in containers that are clean, free from both faecal and chemical contamination and either enclosed or with narrow openings, ideally fitted with a dispensing device such as a spigot that prevents hand access and other sources of extraneous contamination. Good hygiene is required and should be supported by educational programmes.

In other cases, particularly in developed countries, vendors transport and deliver the water to users in tanker trucks. If large volumes are being transported, the addition of chlorine to provide a free residual concentration of at least 0.5 mg/l at the point of delivery to users is desirable. Tankers should also be used solely for water or, if this is not possible, should be thoroughly cleaned prior to use.

All components of systems associated with supplying and delivering vended water need to be designed and operated in a manner that protects water quality. Water storage containers, pipework and fittings should not include defects such as structural faults that allow leakage and permit the entry of contaminants. Cleanliness of storage containers, standpipes, taps and hoses needs to be maintained. Hoses used to transfer water at kiosks or used on carts and tanker trucks should be protected from contamination (e.g. by preventing contact of the ends with the ground) and drained when not in use. The area around standpipes should include drainage or be constructed in a manner to prevent pooling of water. Materials used in all components, including pipework, containers and hoses, need to be suitable for use in contact with drinking-water and should not result in contamination of the water with hazardous chemicals or with substances that could adversely affect its taste.

All components of water vending, including sources, methods of abstraction and transport, should be incorporated into a WSP. Where vendors are registered or have a contract with a water utility, implementation and operation of the WSP should be regularly checked by the utility. WSPs and the operation of water vendors should also be subject to independent surveillance.

6.4 Bulk water supply

Bulk water supplies can be either untreated or treated water, but usually there is limited or no choice in the provision of such supplies. They may be provided where one agency or company controls a large raw water source, usually surface water, and provides water to one or several other water suppliers. Bulk water supplies can be delivered by pipeline or tanker or using ships or fleets of road or rail tankers.

In all cases, it is important that the bulk supply is incorporated into the WSP of the receiving supply and treated as another source. Where bulk supplies of treated water have been used to provide support during a drought or emergency, it is vital that the receiving supplier takes steps to ensure that the water is safe before it is introduced into the receiving distribution system. At all stages, it is important that there is close communication between all parties involved and that the procedures and requirements are documented, understood and carried out with appropriate monitoring and verification.

The potential hazards from bulk water are similar to those from any water supply, but there are additional sources of contamination, such as inappropriate containers and materials and lack of sanitation and hygiene at bulk water filling connections or transfer points. Pipelines may be vulnerable to contamination along the transmission route, particularly if there is the potential for unapproved connections into the system.

Many of the requirements for bulk supply are the same as for any piped supply, such as using approved materials that will not adversely affect water quality. Where tankers are used, these should be of a suitable material and be clean and free from microbial and chemical contamination. To minimize contamination during filling of bulk water containers or water tankers and charging of water transmission pipelines, sanitary inspections and maintenance of sanitary conditions for water filling stations are necessary. These sites should have proper drainage to avoid standing water and flooding, should not be exposed to sources of contamination and should be secure, with access restricted to authorized personnel. At water filling and delivery points, nozzles and couplings should be protected from sources of contamination, including animals. Installation of protective coverings for filling and receiving connectors would help in this respect. Some plastic pipe materials are permeable to organic chemicals, and transfer of substances such as petroleum hydrocarbons could diminish the structural integrity of the pipe materials or render the water unpalatable to consumers. Such piping is most likely to be found in transfer hoses, so the cleanliness of the transfer points where tankers are used is vital, as is protection of the transfer area from spills of petroleum fuels.

Implementation of security measures to guard against intentional contamination and theft may also be warranted.

6.5 Desalination systems

Desalination is used to remove salts from brackish or saline surface water and groundwater in order to render it acceptable for human consumption or other uses. It is increasing employed to provide drinking-water because of a growing scarcity of fresh water driven by population growth, overexploitation of water resources and climate change. Desalination facilities exist all over the world, particularly in the eastern Mediterranean region, with use increasing on all continents. Small-scale desalination is used to supply fresh water on ships and to provide additional fresh water in some hot and arid regions.

These Guidelines are fully applicable to desalinated water supply systems; however, desalination presents certain differences in emphasis, as summarized below.

Desalinated water has a very low total organic carbon content and low disinfectant demand, so disinfection by-products are generally of little concern, although brominated organics may occur owing to the presence of bromide in seawater. Membrane and distillation desalination processes are very efficient at removing higher molecular weight organic chemicals and virtually all inorganic chemicals, and volatile organic compounds are vented during thermal desalination processes. Where membranes are used, boron and some smaller molecular weight organic substances may not be excluded, so it is important to establish the membrane capability. Because of the apparently high effectiveness of some of the processes used (especially distillation and reverse osmosis) in removing both microorganisms and chemical constituents, these processes may be employed as single-stage treatments or combined with only a low level of residual disinfectant. For further information, see the supporting document *Water treatment and pathogen control* (Annex 1). Pretreatment is largely in place to protect the desalination process, but it will also remove certain hazards present in brackish or saline waters.

Water produced by desalination is low in minerals and usually aggressive towards materials with which it comes into contact, such as materials used for distribution pipes, storage and plumbing. During post-treatment, the water must be stabilized or remineralized prior to distribution to reduce its corrosive nature. Stabilization is commonly achieved by adding chemical constituents such as calcium and magnesium carbonate along with pH adjustment or through blending with small volumes of mineral-rich waters. Seawater and spent seawater that has undergone electrolysis to form hypochlorite have been used for this purpose, but the latter practice has essentially ended because of the formation of bromate in the distributed water. Blending waters should be pretreated to ensure their microbial safety, because the post-desalination residual disinfectant level may be insufficient to control pathogens present in the blending water.

Desalinated water contains lower than usual concentrations of dissolved solids and essential elements such as calcium and magnesium, which are commonly found in water (see the supporting document *Calcium and magnesium in drinking-water*; Annex 1). Drinking-water typically contributes a small proportion to the recommended daily intake of essential elements, with most of the intake occurring through food. Fluoride would also be missing from desalinated water unless it were added prior to distribution, which may be considered by countries in which sugar consumption is high (WHO, 2005b).

High temperatures of distributed water in warm climate areas and difficulty in maintaining disinfectant residuals during transport over long distances may lead to microbial aftergrowth, depending on nutrient availability. Although such growth is likely to be without health significance (see the supporting document *Heterotrophic plate counts and drinking-water safety*; Annex 1), it can contribute to problems of acceptability. The use of chloramines constitutes an advantageous alternative to free chlorine in distribution systems with long residence times and elevated temperatures, although nitrite formation by organisms in biofilms needs to be considered where chloramination is practised and excess ammonia is present.

Extensive information on desalination for safe drinking-water supply is available in the book *Desalination technology: Health and environmental impacts* (Cotruvo et al., 2010) and the supporting document *Safe drinking-water from desalination* (Annex 1).

6.6 Dual piped water supply systems

In some locations, households and buildings served with a piped drinking-water supply may also receive piped water from an alternative source for non-potable purposes, creating a dual piped water supply system. The alternative water source is usually provided to reduce the use of high-quality water resources for non-potable uses (e.g. toilets, washing clothes, irrigation) or simply to conserve scarce water resources.

Non-potable piped supplies can potentially introduce health hazards, commonly through accidental cross-connections between potable and non-potable piped supplies. Measures to control health risks from dual piped supply systems include:

- use of good design practices that prevent cross-connections;
- unambiguous labelling of both systems to ensure that the non-potable supply is not mistaken for the potable supply;
- installation of the non-potable piped system only by qualified plumbers;
- regulation of non-potable piped systems by the authority responsible for drinking-water surveillance;
- public communication about the potential health risks from exposure to non-potable water through cross-connections and the dangers of modifying systems by inexperienced and non-certified individuals.

Increasingly in developed countries, dual systems are being installed at a household level or in public buildings. Guidance should be provided on installation, particularly where this is by non-certified individuals. Potable water supplied into the building should be fitted with a non-return valve in order to prevent backflow into the public water supply.

6.7 Emergencies and disasters

Safe drinking-water is one of the most important public health requirements in most emergencies and disasters, along with adequate sanitation. The greatest waterborne risk to health comes from the transmission of faecal pathogens as a result of inadequate sanitation, hygiene and protection of drinking-water sources. Some disasters, including those caused by or involving damage to chemical or nuclear industrial installations, spillage in transport or volcanic activity, may result in contamination by chemical or radiological hazards of concern. The circumstances of most large-scale emergencies will vary, and each will present its own peculiar problems and challenges.

Where a number of agencies are involved in disaster relief or overseeing an emergency, it is vital that there is good communication between the agencies and coordination of their activities. It is also important that the overall coordinators take advice from the experts in a particular field, such as water supply and sanitation. This section considers primarily large-scale disasters and emergencies, although much of the information will apply to smaller-scale emergencies as well. For microbiological and chemical emergencies on a smaller scale in piped supplies, the relevant sections in chapters 7 and 8 should be consulted.

When people are displaced by conflict and natural disaster, they may move to an area where unprotected water sources are contaminated. When population density is high and sanitation is inadequate, unprotected water sources in and around the temporary settlement are highly likely to become contaminated. A displaced population with low immunity due to malnutrition as a consequence of food shortages or the burden of other diseases is at an increased risk of an outbreak of waterborne disease.

Emergency planning initiatives should include three phases:

1) vulnerability assessments (which should be part of a WSP for any large supply) to identify the critical elements of the existing systems that, if compromised, would result in major disruption of basic services;
2) mitigation plans to identify feasible actions to prevent or reduce the disruptive effects related to the loss of the vulnerable elements or facilities;
3) emergency preparedness plans to facilitate managing the crisis and the restoration of service should disruptions occur.

The key is to anticipate probable events, have plans in place, prepare to respond when needed, have backup materials and facilities and have conducted simulations so that the organization and its staff will be effective in the event of an emergency.

Available sources of water are limited in most emergency situations, and providing a sufficient quantity of water for personal and domestic hygiene as well as for drinking and cooking is important. National drinking-water quality standards should therefore be flexible, taking into consideration the risks and benefits to health in the short and long term, and should not excessively restrict water availability for hygiene, as this would often result in an increased overall risk of disease transmission.

There are a number of factors to take into consideration when providing drinking-water for a population affected by a disaster, including the following:

- *The quantity of water available and the reliability of supply:* These are likely to be the overriding concerns in most emergency situations, as it is usually easier to improve water quality than to increase its availability or to move the affected population closer to another water source.
- *The equitability of access to water:* Even if sufficient water is available to meet minimum needs, additional measures may be needed to ensure that access is equitable. Unless water points are sufficiently close to their dwellings, people will not be able to collect enough water for their needs. Water may need to be rationed to ensure that everyone's basic needs are met.
- *Protecting the water source against contamination:* This should always be a priority in emergencies, whether or not disinfection of the water supply is considered necessary.
- *The need for disinfection:* Disinfection, maintaining an adequate disinfectant residual and, where necessary, pretreatment to reduce turbidity to as low as feasible in order to ensure the efficiency of disinfection are essential components in ensuring a safe drinking-water supply. The information in Table 6.1 in section 6.11, on drinking-water disinfection methods that can be used by travellers, may be applied to temporary uses in emergency situations.
- *Longer-term planning for continuing emergency situations:* When the first phase of an emergency or disaster is over and the cleanup is in progress, consideration needs to be given to the longer-term provision of safe water and sanitation. In this case, pre-planning can be invaluable.
- *Acceptability:* It is important to ensure that drinking-water provided in emergencies is acceptable to the consumers in terms of taste, odour and appearance, or the consumers may resort to water from unprotected or untreated supplies.
- *The need for containers to collect and store water:* Containers that are hygienic and appropriate to local needs and habits are needed for the collection and storage of water to be used for washing, cooking and bathing.
- *The availability of bottled or packaged water:* Provision of bottled or packaged water from a reliable source is often an effective way to quickly provide safe, potable water in emergencies and disasters. Brewers and soft drink producers, if they are part of the emergency response plan, are often capable of converting their processes to produce bottled or packaged water in emergencies. This is particularly valuable if they have water treatment plants for ensuring the quality of water used as an ingredient in their processes.

In many emergency situations, water is collected from central water collection points, stored in containers and then transferred to cooking and drinking vessels by the affected people. It is important that people be aware of the risks to health from contamination of water from the point of collection to the moment of consumption and have the means to reduce or eliminate these risks. Detailed information may be found in Wisner & Adams (2003).

Water quality should be monitored during emergencies, including sanitary inspection and microbial water sampling and analysis; monitoring of water treatment processes, including disinfection; monitoring of water quality at all water collection points and in a sample of homes; and water quality assessment in the investigation of disease outbreaks or the evaluation of hygiene promotion activities, as required.

Monitoring and reporting systems should be designed and managed to ensure that action is swiftly taken to protect health. Health information should also be monitored to ensure that water quality can be rapidly investigated when it is suspected of contributing to a health problem and treatment processes, particularly disinfection, can be modified as required.

Where large numbers of water samples need testing or analysis of a broad range of parameters is of interest, laboratory analysis is usually most appropriate. If the drinking-water supplier's laboratories or laboratories at environmental health offices and universities no longer function because of the disaster, a temporary laboratory may need to be set up. Where samples are transported to laboratories, appropriate handling is important to ensure meaningful results. Portable testing kits allow the determination in the field of key water quality parameters, such as thermotolerant coliform count, free residual chlorine, pH, turbidity and filterability.

Workers should be trained in the correct procedures for collecting, labelling, packing and transporting samples and in supplying supporting information from the sanitary survey to help interpret laboratory results. For guidance on methods of water sampling and testing, see Bartram & Ballance (1996), WHO (1997) and APHA, AWWA & WEF (2005).

6.8 Temporary water supplies

A number of waterborne disease outbreaks have occurred as a result of poor management and design of temporary water supplies, which are distributed water supplies for planned seasonal or time-limited events (e.g. festivals, markets and summer camps). Water supplies for holiday towns are not covered, because they are permanent supplies, although substantial seasonal variations in demand bring specific problems.

A systematic approach to drinking-water safety, including adequate quantity and quality, is needed for temporary water supplies. A WSP is an essential requirement in identifying the hazards and risks and developing good management procedures to deal with them. Chapter 4 and other sections in chapter 6 provide additional useful information. Where water is supplied through tankers, the requirements are the same as for vended water (section 6.3) and bulk water supplies (section 6.4).

A temporary water supply may be independent (i.e. not connected to any other water supply system and with its own facilities from source to tap) or dependent (i.e. receiving treated water from an existing water supply system but with independent distribution facilities). The risk of drinking-water contamination is usually lower in dependent systems, provided there is access to the technologies, expertise and management of the permanent system. A contract is often made between the organizer of an event (e.g. a festival) and a water supply entity, which should include the water quantity and quality supplied by the entity, the roles and responsibilities of each party in water quality management, the locations and frequency of water quality monitoring, sanitary inspection and surveillance by a health authority and the provision of adequate and properly sited sanitation. Coordination between an event organizer, a water supply entity and the relevant health authority is very important for ensuring drinking-water safety.

Temporary water supply systems can vary substantially in terms of their scale, period of operation, water use and fluctuations in demand, and these variations should be taken into consideration during the planning and design stages. In the case of an independent system, adequate consideration should also be given to the selection of a water source in terms of quantity, quality and treatment processes, and care should be taken not to adversely affect any other supply or water source. Where a temporary system is directly connected to a mains water supply, it is important to prevent the accidental contamination of the mains water supply through backflow during construction and operation of the temporary system. Water consumption for firefighting, hand washing and toilet flushing should be taken into account in estimating total and predictable variations in water demand where there are no other water sources available for such purposes.

Water quality targets for temporary supplies should be the same as those for permanent water supplies. Disinfection should be considered indispensable in a temporary supply, and it is preferable to maintain a certain level of disinfectant (e.g. chlorine) residual at service taps. If the supply is not for potable uses, appropriate action should be taken to ensure that it is not used for drinking.

If a temporary water supply is used recurrently, it is essential to fully flush the entire system with water containing a higher than normal disinfectant residual before restarting. When planning installation on site, positioning of pipes, hoses and connections should take risks of contamination into account—for example, by avoiding the placement of hosing and fittings on the ground near sites of potential faecal contamination or storage tanks in direct sunlight where rising temperatures support microbial growth. It is also important to ensure that the facility has no defects, including leakage, that could cause the deterioration of water quality and that water quality at every service tap satisfies the required quality target. Important control measures during dismantling and transport of installations include emptying hoses, preferably drying them and storing them so that ingress of contamination is avoided. In all cases, the materials should be approved for use in contact with potable water.

Care should be taken in planning and designing wastewater management and disposal facilities, particularly to ensure that lavatories and disposal facilities are located so as to avoid any risk of adversely affecting source water quality or stored water. It is also important to prevent runoff from other areas, such as livestock pens, from entering the source. The source, treatment facilities and distribution reservoirs should be well protected from access by animals (e.g. bird faeces) and humans by covers or roofs.

A temporary system is usually more vulnerable to accidental and deliberate contamination than an existing permanent water supply system, and attention needs to be paid to security. All water treatment facilities should be thoroughly inspected at least every day. All of these procedures and requirements should be included in the operational management documents that are at the core of the WSP.

Signs are an important part of ensuring that water from taps is used appropriately and the protection of water sources and drinking-water infrastructure. The signs should be easily understood and used in conjunction with other barriers, such as fences.

Water quality and appearance should be routinely monitored at the service taps of a temporary water supply system. At the very least, water temperature and disinfectant residual should be monitored every day as simple rapid tests that act as indicators of possible problems. Other basic parameters that should be regularly monitored, if possible, include pH, conductivity, turbidity, colour and *Escherichia coli* (or, alternatively, thermotolerant coliforms). Routine sanitary inspection of a temporary water supply by the appropriate health authority is very important. If any problem related to water quality arises, remedial actions that are included in the management documents supporting the WSP should be taken promptly. If a temporary water supply system is to be used for a period of more than a few weeks, regular surveillance by the appropriate health authority should be implemented.

6.9 Buildings[1]

Drinking-water systems in buildings can be a significant source of contamination, and poor management of these systems has contributed to outbreaks of disease and illness. One of the challenges in ensuring water safety is that responsibility for many actions essential to the control of drinking-water quality in buildings is often outside the mandate of the drinking-water supplier. Roles and responsibilities of different stakeholders relating to the safe management of drinking-water systems within buildings can be influenced by a number of factors, including ownership of assets and rights of access. WSPs established for management of public water supplies are not typically extended to buildings, although the water supplier WSP may include a number of initiatives to ensure that backflow prevention is in place or to provide information to consumers on protecting their own water quality. In many cases, owners, managers or maintenance personnel are responsible for managing building water supplies, but awareness and application of drinking-water guidelines are often limited, and so educational supporting programmes may be required.

The design of water networks in buildings is variable, as influenced by the diversity of building types (e.g. schools, child-care facilities, residential buildings, hotels, sports facilities, factories, office blocks, museums, transport terminals), designs and water uses. Drinking-water systems in buildings are typically divided into hot and cold water networks and may be connected to water-based devices (e.g. cooling towers, boilers, swimming pools) or point-of-use equipment (e.g. washing machines).

General drinking-water safety is ensured by good management practices, including sound design, routine maintenance protocols, regular cleaning, temperature management and flow management (avoidance of stagnation). These practices should be incorporated in WSPs developed by building owners or managers. WSPs for buildings should address cold and hot drinking-water networks and consider water-based devices and point-of-use equipment. Regulatory or other appropriate authorities may provide guidance on the development and application of WSPs for drinking-water systems in buildings.

[1] Hospitals, nursing care homes and other health-care facilities are discussed in section 6.10.

The regulator can specify compliance requirements for buildings in general or for specific types of buildings based on the level of risk. Schools, hotels and some other large buildings are high-risk environments because of both the complex nature of their drinking-water systems and the vulnerability of some users, occupants and visitors, and heightened vigilance in terms of operational monitoring, validation of control measures and verification is generally justified. Compliance may require that maintenance and monitoring programmes be carried out through a building-specific WSP. It may be appropriate to display maintenance and monitoring programmes and certification of compliance at a conspicuous location within the building. Compliance could be verified and certified by an independent auditor.

The principal hazard that may threaten drinking-water systems of buildings is ingress of contamination from external water supplies or through faults in the distribution system (including storage tanks). Unapproved and inappropriate fittings and materials can lead to the release of chemical substances from tanks, piping, jointing and plumbing materials. The release may vary with the age of the material and the contact period; for example, first-draw water contains higher concentrations of lead or copper. Cross-connections with chemical storage containers, backflow from point-of-use equipment and cross-connections with non-potable supplies can lead to a range of contaminants entering drinking-water.

Where water is supplied directly to equipment in buildings, the potential for backflow into the mains network exists. This may be driven by high pressures generated in equipment connected to mains water supplies or by low pressures in the mains, but it can be prevented by fitting appropriate backflow prevention devices.

An additional problem not directly related to drinking-water is microbial growth (e.g. *Legionella*) on surfaces and in water-based devices that may lead to an inhalation hazard from spray droplets. Growth of such bacteria can be controlled through basic measures (e.g. maintaining water outside the range at which *Legionella* proliferate, i.e. > 50 °C for hot water and < 25 °C for cold water, or maintaining a suitable disinfectant residual). Poor temperature control can occur in cold water systems through inadequate insulation and separation from hot water systems and in hot water systems in heating devices and storage containers, inappropriate location of tempering devices, long branch mains and dead ends (i.e. lengths of pipe, closed at one end, through which no water passes). In large buildings, there is increased potential for growth of *Legionella* in long water distribution systems, and maintenance of these systems needs particular attention. For further information on *Legionella* in drinking-water, see section 11.1 and the supporting document *Legionella and the prevention of legionellosis* (Annex 1).

Effective assessment of potential health hazards and risks requires documentation of the physical structure of water systems in buildings. This should be kept up to date and include hot and cold water networks, including materials used; point-of-entry treatment; point-of-use treatment, equipment and systems (e.g. for firefighting) connected to the drinking-water supply; and water-based devices supplied by the drinking-water system.

In undertaking an assessment of the building's distribution system, a range of specific issues must be taken into consideration that relate to ingress, introduction and proliferation of contaminants, including:

- the quality and management of external supplies;
- use of independent water supplies;
- intermittent supplies;
- pressure of water within the system;
- temperature of water (in both cold and hot water systems);
- integrity of storage tanks;
- areas subject to intermittent or seasonal use (e.g. hotels with seasonal occupancy, schools);
- cross-connections, especially in mixed systems;
- backflow prevention;
- system design to minimize dead/blind ends and other areas of potential stagnation;
- the use of materials and coatings approved for use with drinking-water.

The aim of a distribution system within a large building is to supply safe drinking-water at adequate pressure and flow. The quality of water entering building supplies will be ensured by a water utility or by the installation of point-of-entry devices typically managed by the building owner or operator. To maintain drinking-water quality, it is important to minimize transit times, low flows and low pressures.

Procedures should be established for repairs, renovations or extensions of systems to ensure that water safety is maintained, and all work, including changes to water systems, should be documented. Following work on the system, it would be appropriate to disinfect and flush.

Monitoring should focus on ensuring that control measures are working effectively. Where possible, this should include monitoring by maintenance personnel using field kits for parameters such as temperature, pH and disinfectant residuals. The frequency will vary depending on the size and use of the building, but it should be weekly in large buildings. Monitoring of drinking-water quality will be more frequent when the building is new or recently commissioned.

Independent surveillance is a desirable element in ensuring continued water safety within buildings and should be undertaken by the relevant health agency or other independent authority.

To ensure the safety of drinking-water within buildings, supportive activities of national regulatory agencies include:

- specific attention to application of codes of good practice (e.g. at commissioning and in contracting construction and rehabilitation);
- suitable education and training programmes for building owners and managers, engineers, plumbers and operators of water-based devices (e.g. cooling towers and evaporative condensers);
- regulation of the plumbing community and use of certified professionals;
- effective certification and use of materials and devices in the marketplace;
- codes of practice for design and operation of water-based devices;

For further guidance, see the supporting document *Water safety in buildings* (Annex 1).

6.10 Health-care facilities

Health-care facilities include hospitals, health centres and hospices, residential care, dental surgeries and dialysis units. Drinking-water in such facilities should be suitable for human consumption and for all usual domestic purposes, including personal hygiene. However, it may not be suitable for all uses or for some patients, and further processing or treatment or other safeguards may be required.

Although microorganisms such as *Pseudomonas aeruginosa* and mycobacteria, *Acinetobacter*, *Aeromonas* and *Aspergillus* species do not appear to represent a health concern through water consumption by the general population, including most patients in health-care facilities, they may be of concern for severely immunosuppressed persons, such as those with neutrophil counts below 500 per microlitre (see the supporting document *Heterotrophic plate counts and drinking-water safety*; Annex 1). Some of these microorganisms also have the potential to cause infections if drinking-water is used to wash burns or medical devices such as endoscopes and catheters. Water used for such purposes may require additional processing, such as microfiltration or sterilization, depending on use.

Health-care facilities may include environments that support the proliferation and dissemination of *Legionella* (see section 11.1 and the supporting document *Legionella and the prevention of legionellosis*; Annex 1). Some equipment, such as water-cooled high-speed drills in dental surgeries, is of particular concern for both inhalation of droplets and infection of wounds.

Renal dialysis requires large volumes of water that is of higher quality than drinking-water. Water used for dialysis requires special processing to minimize the presence of microorganisms, endotoxins, toxins and chemical contaminants. There are special requirements regarding aluminium, which, in the past, has caused dialysis dementia, and dialysis patients are also sensitive to chloramines, which needs to be considered when chloramination is used to disinfect drinking-water supplies, particularly in areas where there are home dialysis patients.

All health-care facilities should have specific WSPs as part of their infection control programme. These plans should address issues such as water quality and treatment requirements, cleaning of specialized equipment and control of microbial growth in water systems and ancillary equipment.

6.11 Safe drinking-water for travellers

The most common sources of exposure to disease-causing organisms for travellers are contaminated drinking-water and food that has been washed with contaminated water. Diarrhoea is the most common symptom of waterborne infection, affecting 20–50% of all travellers or about 10 million people per year. Cases can occur even among people staying in high-quality resorts and hotels. In some parts of the world, tap or bottled water that has not been produced under proper conditions may not be safe, even if it is clear and colourless.

No vaccine is capable of conferring general protection against infectious diarrhoea, which is caused by many different pathogens. It is important that travellers be aware of the possibility of illness and take appropriate steps to minimize the risks. Preventive measures while living or travelling in areas with questionable drinking-water quality include the following:

- Drink only bottled water or other beverages (carbonated beverages, pasteurized juices and milk) provided in sealed tamper-proof containers and bottled/canned by known manufacturers (preferably certified by responsible authorities). Hotel personnel or local hosts are often good sources of information about which local brands are safe.
- Drink water that has been treated effectively at point of use (e.g. through boiling, filtration or chemical disinfection) and stored in clean containers.
- Drink hot beverages such as coffee and tea that are made with boiled water and are kept hot and stored in clean containers.
- Avoid brushing teeth with unsafe water.
- Do not use ice unless it has been made from safe water.
- Avoid salads or other uncooked foods that may have been washed or prepared with unsafe water.

Water can be treated in small quantities by travellers to significantly improve its safety. Numerous simple treatment approaches and commercially available technologies are available to travellers to disinfect drinking-water for single-person or family use. Travellers should select a water treatment approach that removes or inactivates all classes of pathogens. Technologies should be certified by a credible organization, and manufacturers' instructions should be followed carefully.

Bringing water to a rolling boil is the simplest and most effective way to kill all disease-causing pathogens, even in turbid water and at high altitudes. The hot water should be allowed to cool without the addition of ice. If the water is turbid and needs to be clarified for aesthetic reasons, this should be done before boiling.

If it is not possible to boil water, chemical disinfection of clear, non-turbid water is effective for killing bacteria and most viruses and some protozoa (but not, for example, *Cryptosporidium* oocysts). Certain chlorine-based or iodine-based compounds are most widely used for disinfection of drinking-water by travellers. Following chlorination or iodination, an activated carbon (charcoal) filter may be used to remove excess taste and odour from the water. The use of iodine is not recommended for long-term use by infants, pregnant women, those with a history of thyroid disease and those with known hypersensitivity to iodine unless treatment includes an effective post-disinfection iodine removal device (e.g. activated carbon). Travellers intending to use iodine treatment daily for all water consumed for more than 3–4 weeks should consult a physician beforehand and not use it in excessive amounts. Silver is sometimes promoted as a disinfectant, but it is not recommended, as its efficacy is uncertain and it requires lengthy contact periods.

Suspended particles in water can reduce the effectiveness of disinfectants, and turbid water should be clarified or filtered before disinfection. Chemical products that combine clarification (coagulation and flocculation to remove particles) with chlorine disinfection are available.

Portable point-of-use filtration devices tested and rated to remove protozoa and some bacteria, such as ceramic, membrane (mainly reverse osmosis) and activated carbon block filters, are also available. A pore size rating of 1 μm or less is recommended to ensure the removal of *Cryptosporidium* oocysts. These filters may require a pre-filter to remove suspended particles in order to avoid clogging the final filter.

Unless water is boiled, a combination of techniques (e.g. clarification and/or filtration followed by chemical disinfection) is recommended. This combination provides a multiple treatment barrier that removes significant numbers of protozoa in addition to killing bacteria and viruses.

For people with weakened immune systems, pregnant women and infants, extra precautions are recommended to reduce the risk of infection from water contaminated with *Cryptosporidium*, for example. Boiling and storing water in a protected container are recommended, although internationally or nationally certified bottled or mineral water may also be acceptable.

The treatment methods described here, with the exception of carbon filtration and reverse osmosis, will generally not reduce levels of most chemical contaminants in drinking-water. However, these are not usually of health concern in the short term.

Further information on household water treatment of microbial and chemical contaminants of water can be found in sections 7.3.2 and 8.4.4, respectively. Table 6.1 provides a summary of drinking-water disinfection methods that can be used by travellers.

6.12 Aircraft and airports

The importance of water as a potential vehicle for infectious disease transmission on aircraft has been well documented. In general terms, the greatest microbial risks are those associated with ingestion of water that is contaminated with human and animal excreta. If the source of water used to replenish aircraft supplies is contaminated and adequate precautions are not taken, disease can be spread through the aircraft water if it used for drinking or tooth cleaning. It is thus imperative that airports comply with the International Health Regulations (2005) and be provided with potable drinking-water from a source approved by the appropriate regulatory agency (WHO, 2005a). Airports usually have special arrangements for managing water after it has entered the airport.

A potable water source is not a safeguard if the water is subsequently contaminated during transfer, storage or distribution in aircraft. A WSP covering water management within airports from receipt of the water through to its transfer to the aircraft (e.g. by water servicing vehicles or water bowsers), complemented by measures to ensure that water quality is maintained on the aircraft (e.g. safe materials and good practices in design, construction, operation and maintenance of aircraft systems), provides a framework for water safety in aviation.

In undertaking an assessment of the general airport/aircraft water distribution system, a range of specific issues must be taken into consideration, including:

Table 6.1 Drinking-water disinfection methods for use by travellers

Method	Recommendation	What it does	What it does *not* do
Boiling	Bring water to a rolling boil and allow to cool	Kills all pathogens	Does not remove turbidity/cloudiness Does not provide residual chemical disinfectant, such as chlorine, to protect against contamination
Chlorine compounds: 1. Unscented household bleach (sodium hypochlorite) 2. Sodium dichloroisocyanurate tablet 3. Calcium hypochlorite	For typical room temperature and water temperature of 25 °C, minimum contact time should be 30 min; increase contact time for colder water—e.g. double time for each 10 °C less than 25 °C Prepare according to instructions Should be added to clear water or after settling or clarification to be most effective Type and typical dosage: 1. Household bleach (5%)—4 drops per litre 2. Sodium dichloroisocyanurate—1 tablet (per package directions) 3. Calcium hypochlorite (1% stock solution)[a]—4 drops per litre	Effective for killing most bacteria and viruses Longer contact time required to kill *Giardia* cysts, especially when water is cold	Not effective against *Cryptosporidium*; not as effective as iodine when using turbid water
Flocculant-chlorine tablet or sachet	Dose per package directions	Effective for killing or removing most waterborne pathogens (coagulant-flocculants partially remove *Cryptosporidium*)	Flocculated water must be decanted into a clean container, preferably through a clean fabric filter

Table 6.1 (continued)

Method	Recommendation	What it does	What it does *not* do
Iodine: 1. Tincture of iodine (2% solution) 2. Iodine (10% solution) 3. Iodine tablet 4. Iodinated (triiodide or pentaiodide) resin	25 °C—minimum contact for 30 min; increase contact time for colder water Prepare according to package instructions Type and typical dosage: 1. Tincture of iodine (2% solution)—5 drops per litre 2. Iodine (10% solution)—8 drops per litre 3. Iodine tablet—1 or 2 tablets per litre 4. Iodinated (triiodide or pentaiodide) resin—room temperature according to directions and stay within rated capacity *Caution*: Not recommended for pregnant women, for people with thyroid problems or for more than a few months' time. Excess iodine may be removed after iodine treatment through use of a carbon filter or other effective process.	Kills most pathogens Longer contact time is required to kill *Giardia* cysts, especially when water is cold Carbon filtration after an iodine resin will remove excess iodine from the water; replace the carbon filter regularly	Not effective against *Cryptosporidium*
Portable filtering devices: 1. Ceramic filters 2. Carbon filters; some carbon block filters will remove *Cryptosporidium*—only if tested and certified for oocyst removal 3. Membrane filter (microfilter, ultrafilter, nanofilter and reverse osmosis) type devices	Check pore size rating and reported removal efficiencies for different pathogens (viruses, bacteria and protozoa) provided by manufacturer and certified by a national or international certification agency. Filter media pore size must be rated at 1 μm (absolute) or less. Note that water must be clear to prevent clogging of pores. Filtration or settling of turbid water to clarify it is recommended before disinfection with chlorine or iodine if water is not boiled	1 μm or less filter pore size will remove *Giardia*, *Cryptosporidium* and other protozoa Approved reverse osmosis device can remove almost all pathogens Some filters include a chemical disinfectant such as iodine or chlorine to kill microbes; check for manufacturer's claim and documentation from an independent national or international certification agency	Most bacteria and viruses will not be removed by filters with a pore size larger than 1 μm Microfilters may not remove viruses, especially from clear waters; additional treatment such as chemical disinfection or boiling/pasteurization may be needed to reduce viruses Most carbon block filters do not remove pathogens, other than possibly protozoa, even if carbon is impregnated with silver, because pore size is too large (> 1 μm)

[a] To make a 1% stock solution of calcium hypochlorite, add (to 1 litre of water) 28 g if chlorine content is 35%, 15.4 g if chlorine content is 65% or 14.3 g if chlorine content is 70%.

- quality of source water and the need for additional treatment;
- design and construction of airport storage tanks and pipes;
- design and construction of water servicing vehicles;
- use of materials and fittings approved for contact with drinking-water at all stages;
- water loading techniques;
- any treatment systems on aircraft (e.g. ultraviolet disinfection);
- maintenance of on-board plumbing;
- prevention of cross-connections, including backflow prevention.

The airport authority has responsibility for safe drinking-water supply, including operational monitoring, until water is transferred to the aircraft operator. The primary emphasis of monitoring is to ensure that management processes are operating efficiently—for example, the source water quality is not compromised; all parts of the system, including hydrants, hoses and bowsers, are clean and in good repair; backflow prevention is in place; and any filters are clean. In addition, the system should be disinfected and flushed after maintenance or repairs, and the microbiological quality of the water should be checked, preferably before the system is returned to service.

Transfer of water into the aircraft and the aircraft drinking-water system also has the potential to introduce hazards, even if the water is of good quality up to this point. It is therefore important that staff involved be properly trained and understand the reasons for the precautions to be taken and the care required in preventing contamination. The precautions described in previous sections regarding transfer of drinking-water from a piped supply or from bowsers and tankers are essential, including maintaining the cleanliness of vehicles and transfer points. There is a significant potential for aviation fuel to contaminate the system, and only small quantities of low molecular weight hydrocarbons can cause the water to be unacceptable. In addition, staff employed in drinking-water supply must not be engaged in activities related to aircraft toilet servicing without first taking all necessary precautions (e.g. thorough hand washing, change of outer garments). All of these requirements and procedures should be properly documented as part of the WSP for the airport water transfer system and should be made clear to airlines using the airport to ensure that they play their part as key stakeholders.

Independent surveillance is an important part of the WSP, because circumstances and equipment or staff may change, and the weakening of barriers or the introduction of new risks may not be noticed. This would include initial review and approval of the WSP, periodic review and direct assessment of the provisions and operation of the WSP, paying specific attention to the aircraft industry's codes of practice, the supporting document *Guide to hygiene and sanitation in aviation* (Annex 1) and airport health or airline regulations. It is also important that the response to any incident is recorded and reviewed and any lessons learnt incorporated into the WSP.

6.13 Ships

The importance of water as a vehicle for infectious disease transmission on ships has been clearly documented. In general terms, the greatest microbial risks are associated with ingestion of water that is contaminated with human and animal excreta. However, chemical contamination could also occur on ships as a result of contaminated bulk water being brought aboard in port, cross-connections on board or improper on-board treatment. The supporting document *Guide to ship sanitation* (Annex 1) describes the factors that can be encountered during water treatment, transfer, production, storage or distribution in ships and specific features of the organization of the supply and the regulatory framework. To this end, it is vital that all staff responsible for working with the potable water system are properly trained.

The organization of water supply systems covering shore facilities and ships differs considerably from conventional water transfer on land but is similar to that for airports. The port authority has responsibility for providing safe potable water for loading onto vessels. If water is suspected to have come from an unsafe source, the ship's master may have to decide if any additional treatment (e.g. hyperchlorination or filtration) is necessary. When treatment on board or prior to boarding is necessary, the treatment selected should be that which is best suited to the water and which is most easily operated and maintained by the ship's officers and crew.

Water is delivered to ships by hoses or transferred to the ship via water boats or barges. The transfer from shore to ship is a potential source of microbial or chemical contamination. In addition to shore-to-ship transfer of water and bulk storage on board ship, many ships use desalination (see section 6.4) to produce their own drinking-water.

In contrast to a shore facility, plumbing aboard ships consists of numerous piping systems carrying potable water, seawater, sewage and fuel and fitted into a relatively confined space. Piping systems are normally extensive and complex, making them difficult to inspect, repair and maintain. A number of waterborne outbreaks on ships have been caused by contamination of potable water after it had been loaded onto the ship—for example, by sewage or bilge water when the water storage systems were not adequately designed and constructed. Potable water should be stored in one or more tanks that are constructed, located and protected so as to be safe against contamination. Potable water lines should be protected and located so that they will not be submerged in bilge water or pass through tanks storing non-potable liquids. It is important to design the system to prevent deterioration of water quality during distribution by minimizing stagnation and dead ends and to take into account ship movement, which increases the possibility of surge and backflow.

An overall assessment of the operation of the ship's water supply should be made, for which the final responsibility lies with the ship's master, who must ensure that all of the management processes in place are functioning efficiently. An important part of this process is ensuring that those crew who are responsible for the fresh drinking-water supply are properly trained and receive refresher training as appropriate. In developing a WSP and ensuring that the system is capable of supplying safe water, the following need to be considered:

- quality of source water if this is from a shore-based source along with the equipment and method of transfer from shore to ship;
- desalination equipment and processes where these are used, taking into consideration the points raised in section 6.5;

- design and construction of storage tanks and pipework, including the use of approved materials and chemicals and clear colour coding of pipes for different purposes;
- minimization of dead ends and areas of stagnation, which may be managed by periodic flushing;
- filtration systems and other treatment systems on board the ship, including disinfection and delivery of residual disinfection;
- prevention of cross-connections and presence of working backflow prevention devices;
- maintenance of adequate water pressure within the system;
- presence of a disinfectant residual throughout the system.

The system needs to be checked regularly for cleanliness and repair, and parameters such as pH and disinfectant residual need to be checked daily. Where possible, checks on microbiological quality such as plate counts and faecal coliforms, even if only in port, help to ensure that the supply continues to deliver safe water. There also need to be suitable procedures in place to ensure safety after maintenance or repair, including specific disinfection of the system or the affected zone. Any indication of a problem, such as illness or taste or odour problems, should be immediately investigated and the system corrected if it is shown to be the source. In confined communities such as on ships, person-to-person spread of infectious disease is a major issue. Someone who has been working on the latrines and sanitation system on ships should not transfer to work on the drinking-water system without thorough hand washing and a change of outer clothing.

Independent surveillance is a desirable element in ensuring drinking-water safety on ships. This implies that there will be periodic audit and direct assessment and the review and approval of the WSP. Specific attention should be given to the shipping industry's codes of practice, the supporting document *Guide to ship sanitation* (Annex 1) and port health and shipping regulations. Independent surveillance should also include ensuring that any specific incidents that affect or might have affected water quality have been properly investigated and the lessons to be learnt are incorporated in the WSP.

6.14 Packaged drinking-water

Bottled water and water in containers are widely available in both industrialized and developing countries. Consumers purchase packaged drinking-water for reasons such as taste, convenience or fashion, but safety and potential health benefits are also important considerations.

Water is packaged for consumption in a range of vessels, including cans, laminated boxes and plastic bags, but it is most commonly supplied in glass or plastic bottles. Bottled water also comes in various sizes, from single servings to large carbuoys holding up to 80 litres. Control of the quality of materials, containers and closures for bottled water is of special concern. Ozone is sometimes used for final disinfection prior to bottling because it does not impart a taste to the water. If the water contains naturally occurring bromide, this can lead to the formation of bromate unless care is taken to minimize its formation.

The Guidelines provide a basis for derivation of standards for all packaged waters. As with other sources of drinking-water, safety is pursued through a combination of safety management and end product quality standards and testing and is more readily achievable because batches can be held until results are available. The international framework for packaged water regulation is provided by the Codex Alimentarius Commission of the World Health Organization and the Food and Agriculture Organization of the United Nations.

The Codex Alimentarius Commission has developed a *Standard for natural mineral waters*—which describes the product and its compositional and quality factors, including prescribed treatments, limits for certain chemicals, hygiene, packaging and labelling—and an associated Code of Practice. It has also developed a *Standard for bottled/packaged waters* to cover packaged drinking-water other than natural mineral waters. Both relevant Codex standards refer directly to these Guidelines; the Codex standards for bottled/packaged water are directly equivalent to the guideline values established in these Guidelines. Under the Codex *Standard for natural mineral waters* and associated Code of Practice, natural mineral waters must conform to strict requirements, including collection and bottling without further treatment from a natural source, such as a spring or well. In comparison, the Codex *Standard for bottled/packaged waters includes waters* from other sources, in addition to springs and wells, and treatment to improve their safety and quality. The distinctions between these standards are especially relevant in regions where natural mineral waters have a long cultural history. For further information on the Codex *Standard for natural mineral waters* and its companion Code of Practice and the Codex *Standard for bottled/packaged waters*, readers are referred to the Codex web site (http://www.codexalimentarius.net/).

The Codex Alimentarius Commission's *Code of practice for collecting, processing and marketing of natural mineral waters* provides guidance on a range of good manufacturing practices and provides a generic WSP applied to packaged drinking-water.

Some consumers believe that certain natural mineral waters have medicinal properties or offer other health benefits. Some such waters have higher mineral content, sometimes significantly higher than concentrations normally accepted in drinking-water. They often have a long tradition of use and are often accepted on the basis that they are considered foods rather than drinking-water per se. Although certain mineral waters may be useful in providing essential micronutrients, such as calcium and magnesium, these Guidelines do not make recommendations regarding minimum concentrations of essential elements because of the uncertainties surrounding mineral nutrition from drinking-water. Packaged waters with very low mineral content, such as distilled or demineralized waters, are also consumed. There is insufficient scientific information on the benefits or hazards of long-term consumption of very low mineral waters to allow any recommendations to be made (WHO, 2005b; see also the supporting document *Calcium and magnesium in drinking-water*; Annex 1).

Another form of packaged water is ice that is intended for adding to drinks and which may come into contact with food to be eaten without cooking. Ice prepared and sold in this manner should be treated the same as any packaged water for potable use.

6.15 Food production and processing

The quality of water defined by the Guidelines is such that it is suitable for all normal uses in the food industry. Some processes have special water quality requirements in order to secure the desired characteristics of the product, and the Guidelines do not necessarily guarantee that such special requirements are met.

Poor quality drinking-water may have a severe impact in food processing and potentially on public health. The consequences of a failure to use water of suitable quality in food processing will depend on the use of the water and the subsequent processing of potentially contaminated materials. Variations in water quality that may be tolerated occasionally in drinking-water supply may be unacceptable for some uses in the food industry. These variations may result in a significant financial impact on food production—for example, through product recalls.

The diverse uses of water in food production and processing have different water quality requirements. Uses include irrigation and livestock watering; as an ingredient or where used in washing or "refreshing" of foods, such as misting of salad vegetables in grocery stores; and those in which contact between the water and foodstuff should be minimal (as in heating or cooling and cleaning water).

To reduce microbial contamination, specific treatments (e.g. heat) capable of removing a range of pathogenic organisms of public health concern may be used in food processing. The effect of these treatments should be taken into account when assessing the impacts of deterioration in drinking-water quality on a food production or processing facility. For example, water that is used in canning will usually be heated to a temperature that is at least equivalent to pasteurization.

Information on deterioration of the microbial or chemical quality of a drinking-water supply should be promptly communicated to food and beverage production facilities.

For further information on disinfection of water for use in food production and processing, see FAO/WHO (2009).