

## **3 Developing and implementing risk management strategies**

### **3.1 Identifying priority chemicals in a drinking-water supply**

Many different chemicals may occur in drinking-water; however, only a few are important in any given circumstance. Of particular importance are adverse health outcomes relating to chemical constituents of drinking-water arising primarily from prolonged exposure. It is extremely unlikely that all the chemicals included in the WHO *Guidelines for Drinking-water Quality* (WHO, 2004) will be present in a drinking-water supply system. Consequently, it is important that countries identify those chemicals of concern according to local circumstances. Chemical contaminants in drinking-water should be prioritized to ensure that scarce resources are not unnecessarily directed towards management of chemicals that pose no threat to health and do not affect the acceptability of drinking-water.

As it is neither physically nor economically feasible to test for all chemical constituents in drinking-water on an equal basis, monitoring efforts and resources should be carefully planned and directed at significant or key parameters.

The process outlined in this publication provides guidance to assist water supply utilities, in collaboration with public health authorities, to identify those chemicals that are likely to be present in an individual water supply, and may represent a potential public health risk. Identifying such chemicals is achieved by developing an understanding of the characteristics of the drinking-water catchment, including natural influences on groundwater and surface water, the types and size of industrial and agricultural activities, and human settlements within a catchment. Treatment and distribution of drinking-water also influence the final quality of water delivered to the consumer. In addition, chemicals, materials and processes used in the production and distribution of water will influence the chemical quality of drinking-water.

In assessing the chemical quality of a water supply, it is important to include the four priority chemicals (arsenic, fluoride, selenium and nitrate) first, before assessing the water supply system for chemicals of local concern. Extensive international experience has shown that these four chemicals produce adverse health effects as a consequence of exposure through numerous water supplies around the world. Two other commonly occurring constituents, iron and manganese, are of high priority because they can give rise to significant discolouration of drinking-water, making it unacceptable to consumers, who may turn to supplies that are more aesthetically acceptable but may be microbiologically contaminated.

Once priority chemicals within a particular drinking-water system have been identified, a management policy should be established and implemented to provide a framework for the prevention and reduction of these chemicals. Appropriate monitoring programmes should be established to ensure the chemical quality of drinking-water remains within appropriate national standards.

### **3.2 Drinking-water standards and guidelines**

Every country should have a policy on drinking-water quality. This would normally embody different approaches depending on whether formal responsibility for drinking-water quality is assigned to a defined entity, or whether community management prevails.

Effective national programmes to control drinking-water quality depend ideally on the existence of adequate legislation, standards and codes. The precise nature of the legislation in each country will depend on national, constitutional and other considerations. Generally, the legislation should outline the responsibility and authority of a number of agencies, describe the relationship between them and establish basic policy principles.

The nature and form of drinking-water standards may vary between countries and regions — no single approach is universally applicable. It is essential in the development and implementation of standards to take into account current and planned legislation relating to the water, health and local government sectors and to assess the capacity of potential regulators in the country. Approaches that may have worked in one country or region do not necessarily transfer to other countries. It is essential that each country undertake a review of its needs and capacity for drinking-water standards before embarking on the development of a regulatory framework. This review should include an assessment of existing and future supporting activities.

Standards developed by countries should be applicable to large metropolitan and small community piped systems, and also to nonpiped drinking-water systems in small communities and individual dwellings. National and regional standards should be developed from the scientific basis provided by the WHO *Guidelines for Drinking-water Quality* (WHO, 2004), adapted to take account of local or national environmental, sociocultural (including dietary) and economic conditions. The guidelines provide further information on the development and implementation of national standards.

### **3.3 Overview of management procedures**

The implementation of a successful risk management strategy requires the development of an understanding of those hazards that may impact on the quality of water being provided to a community. A wide range of chemicals in drinking-water could potentially cause adverse human health effects. The detection of these chemicals in both raw water and in water delivered to consumers is often slow, complex and costly, which means that detection is too impractical and expensive to serve as an early warning system. Thus, reliance on water-quality determination alone is insufficient to protect public health. As it is neither physically nor economically feasible to test equally for all drinking-water quality parameters, monitoring effort and resources should be carefully planned and directed at significant or key characteristics.

A preventive management strategy, operating from the water catchment to the tap, should be implemented to ensure drinking-water quality. The strategy should combine protection of water sources, control of treatment processes and management of the distribution and handling of water.

The management procedures developed by water suppliers can be described as a water safety plan. Such a plan, which is the basis of ensuring water safety, contains five key components:

- water quality targets based on critical evaluation of health concerns;
- system assessment to determine whether the water supply chain (from source, through treatment, to the point of consumption) as a whole can deliver water of a quality that meets the above targets;
- operational monitoring of the control points in the supply chain that are of particular importance in securing drinking-water safety;
- management procedures documenting the system assessment and monitoring, and describing actions to be taken in normal operation and incident conditions; including upgrade and improvement, documentation and communication;
- a system of independent surveillance that verifies that the above points are operating properly.

The water safety plan should address all aspects of the water supply and should focus on the control of water production, treatment and delivery of drinking-water. The plan provides the basis for a process control methodology to ensure that concentrations of chemicals are acceptable.

Development of water safety plans is discussed in detail in the *Guidelines for Drinking-water Quality* (WHO, 2004) and in the *WHO Water Safety Plans* (Davison et al, 2002).

### **3.3.1 Health-based targets**

For individual constituents of drinking-water, health-based targets are established. These targets represent a health risk from long-term exposure, in a situation where fluctuations in concentration are small or occur over long periods. It is important that such targets are defined by the relevant local authority, are realistic under local operating conditions and are set to protect and improve public health.

A health-based target specifies the agreed criteria for the quality of water delivered to the consumer. It is used to evaluate the adequacy of existing installations and assist in identifying inspection and analytical verification.

Table 3.1 presents an overview of the health-based targets. For further information on the development and application of health-based targets, refer to the *WHO Guidelines for Drinking-water Quality* (WHO, 2004)

**Table 3.1 Health-based targets for application to microbial and chemical constituents of drinking-water**

Type of target	Nature of target	Typical application	Assessment
<i>Health outcome</i>			
— <i>epidemiology based</i>	Reduction in disease incidence or prevalence	Microbial or chemical hazards with high measurable disease burden, largely water-associated	Public health surveillance and analytical epidemiology
— <i>risk assessment based</i>	Tolerable level of risk by contaminants in drinking-water, absolute or as a fraction of the total burden by all exposures	Microbial or chemical hazards in situations where disease burden is low and cannot be measured directly	Quantitative risk assessment
<i>Water quality</i>			
	Guideline value applied to water quality	Chemical constituents with effects on health or acceptability of drinking-water	Periodic measurement of chemical constituents to assess compliance with relevant guideline values (see GDWQ Chapter 8)
	Guideline values applied in testing procedures for materials and chemicals	Chemical additives and by-products	Testing procedures applied to the materials and chemicals to assess their contribution to drinking-water exposure taking account of variations over time (see GDWQ Chapter 8)
<i>Performance</i>			
	Generic performance target for removal of groups of microorganisms	Microbial contaminants	Compliance assessed through system assessment and operation monitoring (see GDWQ Chapter 4)
	Customised performance targets		Individually reviewed by public health authority; assessment would then proceed as above
	Guideline values applied to water quality	Threshold chemicals with effects on health which vary widely (e.g. nitrate and fluoride)	Compliance assessed through system assessment and operation monitoring (see GDWQ Chapter 4)
<i>Specified technology</i>			
	National authority specifies processes to adequately address constituents with potential health effects (e.g. generic water safety plans for an unprotected catchment)	Constituents with potential health effect in small municipalities and community supplies	Compliance assessed through system assessment and operation monitoring (see GDWQ Chapter 4)

For individual countries, guideline values are the first step towards establishing specific health-based targets for their particular circumstances, based on local and regional determinants.

### **3.3.2 System assessment**

Drinking-water quality can vary significantly throughout the system; consequently, the assessment of the drinking-water supply should aim to determine whether the final quality of water delivered to the consumer routinely meets established health-based targets.

Understanding source quality and changes through the system requires expert input. The assessment needs to take into consideration the behaviour of individual constituents, or groups of constituents, that may influence water quality.

A drinking-water system should be assessed to determine whether it is theoretically capable of meeting the health-based targets. If the assessment indicates that the system is unlikely to be able to meet the targets, this means that the targets are unrealistic under current operating conditions.

A comprehensive assessment of the water supply is essential in the development of a preventive approach to the management of drinking-water quality. Such an assessment should be undertaken through a desktop study of the water supply, combined with site visits. Although many chemicals can be of health concern, the true nature and severity of their impact often remains uncertain (Howard, 2001). When assessing the chemical constituents of drinking-water, the following factors should be carefully considered before undertaking more extensive, and often expensive, analysis of the water:

- What is the extent of the problem — is there strong evidence that the chemicals in water sources are present, or are likely to be present?
- What is the relevant contribution from drinking-water sources compared with other sources (e.g. food)?
- How severe is the potential health concern in the context of other health problems?

Unless there is strong evidence that particular chemicals are currently found or will be found in the near future, at levels that may compromise the health of a significant proportion of the population, the inclusion of those chemicals in drinking-water monitoring programmes is not justified, particularly where resources are limited. It is often more effective to maintain an ongoing programme of pollution control and risk assessment in the catchment.

### **3.3.3 Operational monitoring**

Operational monitoring involves planned observations or measurements to assess whether the critical components of a safe water supply are operating properly. If the components are operating properly collectively, the system should be able to meet water quality targets.

In most cases, operational monitoring is based on simple and rapid observations or tests, such as turbidity or structural integrity, rather than complex chemical analyses. The complex tests are generally applied as part of verification activities rather than routine operational monitoring.

In order to have confidence that the chain of supply is not only operating properly, but to confirm that water quality is being maintained and achieved, verification is required. Verification is the use of methods, procedures or tests, in addition to those used in operational monitoring, to determine whether the water safety plan complies with the stated objectives outlined in the water quality targets, or whether it needs to be modified and revalidated.

### **3.3.4 Management procedures**

Management procedures outline requirements in both normal operational situations and in incident situations where a loss of control of the system occurs. The management procedures should also outline practices and other supportive measures required to ensure optimal operation of the drinking-water system. Targets, assessment and operational monitoring provide information needed for the development of management procedures.

### **3.3.5 Surveillance**

Surveillance of drinking-water quality is the continuous and vigilant public health assessment and overview of the safety and acceptability of drinking-water supplies. It contributes to the protection of public health by promoting improvements of the quality, quantity, access, affordability and continuity of water supplies. The role of the surveillance agency is complimentary to the quality control function of the drinking-water supply agency. Surveillance does not remove or replace the responsibility of the water supply agency to ensure that a water supply is of acceptable quality and meets predetermined health-based, and other, performance targets.

Surveillance is based on a systematic programme of surveys and audits, including regular sanitary inspections and field surveys, as well as laboratory testing that provide recommendations for remedial actions.

## **3.4 References**

Davison A et al. (2002). *Water safety plans. Protection of the human environment*. Water, Sanitation and Health, World Health Organization, Geneva (WHO/SDE/WSH/02.09).

Howard G (2001). *Water supply surveillance: a reference manual*. Water, Engineering and Development Centre (WEDC), Loughborough University, Loughborough, United Kingdom.

WHO (2004). *Guidelines for drinking-water quality*, 3rd ed., World Health Organization, Geneva.