## *Local* authority, this document is for you

WHO Regional Office for Europe is regularly approached to provide technical or practical advice on a large number of questions related to health and the environment.

Experts and many other partners have together drawn up a series of documents which will help you to solve your environment and health problems.

The recommendations are ranked by priority, so that strategies can be developed which are appropriate to the local context.

⚕⚕⚕ identifies a recommendation which is basic for a safe and healthy environment. Actions based on these recommendations should be implemented by all local authorities immediately.

⚕⚕ identifies a recommendation which should show visible health gains and should be regarded as a priority for action throughout Europe.

⚕ identifies a recommendation which is linked to improving the quality of life of your community. These are related to a healthier environment in your community.

The unranked recommendations are designed to help you draw up strategies at local level and will not, in general, have a direct effect on health.

This booklet has been written to enable local authorities to take fully informed decisions. The annexes contain practical information which will help technical personnel and those in charge of public relations in their daily work

Titles already published or in preparation are listed on the back cover.

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# Drinking-water disinfection

## S U M M A R Y

**Each year, 3 million people throughout the world die as a direct result of drinking unsafe water. This colossal figure is particularly worrying when seen in conjunction with the 120 million people in WHO's European Region who do not currently enjoy an uninterrupted supply of microbiologically safe drinking-water.**

**Local authorities have the prime responsibility for eliminating this risk and dealing with instances of contamination which, even when minimal, may result in catastrophic epidemics. It is up to them to do everything in their power to provide the population with a continuous supply of safe water.**

**High-quality water can be guaranteed if certain simple rules are followed. One of these is disinfection of the resource by chlorine. This must continue to be a priority in every case, taking precedence over pre-treatment of water using highly specialized and often expensive techniques.**

Scientific Adviser A Montiel

**In almost all countries in Europe, it is up to local authorities to provide the population with water that does not endanger their health.**

There are numerous risks related to drinking unsafe water, and it is one of the responsibilities of elected officials to take them into account. Traditionally, a distinction is drawn between short-term risks and medium- or long-term ones.

- **Short-term risks**

Drinking a single glass of water of dubious quality may entail a risk. Most frequently, this will be a short-term microbiological risk. Protection against such risks must be ensured round the clock, every day of the year.

- **Medium- and long-term risks**

Medium- and long-term risks are related to drinking chemically contaminated water on a regular and continuous basis for weeks, months or even years. These risks must be taken into account, of course, but in no case should this be at the expense of protection against short-term risks.

In order to provide a continuous supply of safe drinking-water, some simple rules must be followed which will ensure that the water is of good quality in terms of its microbiology. WHO considers the following three rules to be of top priority

- Use a water resource of the best possible quality.
- Take all available measures to protect water sources.
- Disinfect the water on a continuous basis.

Protecting populations against waterborne diseases is dependent on applying and following these rules

## Waterborne diseases

In European countries, there are now fewer risks of major epidemics related to drinking-water contaminated with highly virulent microbes such as those responsible for cholera, typhoid or viral hepatitis. However, it is worrying that there are still instances of waterborne diseases resulting from microbiological contamination of drinking-water: for instance, 248 epidemics of gastroenteritis due to water were notified in the United States of America in the period 1981–1988.

### Health effects

A large number of microbes may cause waterborne epidemics: historically, the *Salmonella spp.* and *Shigella spp.* were the first to be identified. Today, other micro-organisms such as the rotaviruses and *Campylobacter spp.* or parasites such as *Giardia* have also been identified as pathogenic.

The majority of complaints caused by these bacteria are only moderately serious and frequently take the form of gastroenteritis with diarrhoea, abdominal pain or vomiting. Such attacks are generally of short duration. They may affect several people or entire communities, depending on the quantity or type of bacteria present in the water. In addition to these "benign" epidemics, there are occasional instances of far more serious waterborne diseases.

The severity of the infection is determined by the type of pathogen, its mode of transmission and the profile of the people infected: young children, the elderly, the immunosuppressed and ill people are the populations most exposed to these risks. The occurrence of epidemics in communities with a large population at risk (crèches, schools, hospitals, etc.) often plays an early warning role for the authorities.

Infection may occur as a result of drinking the contaminated water or from its various uses in everyday life: preparation of meals, washing, or even inhalation.

**CASE STUDY**

**Cholera - a forgotten disease**

*Waterborne diseases are still widespread. Until recently, it was believed that improvements to drinking-water supply and sanitation systems, as well as better food hygiene, would by themselves lead to the eradication of cholera, as had been achieved in Europe and North America by the end of the nineteenth century. In Peru, however, a new epidemic occurred in 1991. Since then, 391 000 cases (and 19 295 deaths) have been recorded in the Americas. Cholera is also still a serious problem in many countries in Africa and Asia. In the latter, 50 000 cases (including 1286 deaths) were notified in 1991, with 153 000 cases (including 13 998 deaths) in Africa in the same period. These official figures are probably less than the actual numbers. In all cases, water was responsible*

**Principal waterborne diseases and pathogens**

| Diseases | Pathogens |
|---|---|
| **Bacterial origin** | |
| Typhoid and paratyphoid fevers | *Salmonella typhi*<br>*Salmonella paratyphi A and B* |
| Bacillary dysentery | *Shigella* spp. |
| Cholera | *Vibrio cholerae* |
| Acute gastroenteric diseases and diarrhoeas | Enterotoxinogenic *Escherichia coli*<br>*Campylobacter spp.*<br>*Yersinia enterocolitica*<br>*Salmonella* spp.<br>*Shigella* spp. |
| **Viral** | |
| Hepatitis A and E | Hepatitis A and E virus |
| Poliomyelitis | Poliomyelitis virus |
| Acute gastroenteric diseases and diarrhoeas | Norwalk virus<br>Rotavirus<br>Enteroviruses<br>Adenoviruses, etc. |
| **Parasitic** | |
| Amoebic dysentery | *Entamoeba histolytica* |
| Gastroenteric diseases | *Giardia lamblia*<br>*Cryptosporidium spp.* |

Microbiological water pollution is most frequently of human or animal origin, transmitted by faeces. The presence, near a water source, of wastewater or excrement from people who are ill or healthy carriers[1] of pathogens[2] may be at the origin of contamination of the resource.

## Waterborne micro-organisms

### Characteristics

Pathogens have various properties which distinguish them from chemical pollutants.

- They are discrete and not in solution. They may be in free suspension or clumped on suspended matter in the water.
- The likelihood of acquiring an infective dose cannot be predicted solely from the average concentration of micro-organisms in water. The likelihood of a successful challenge by a pathogen, resulting in infection, depends on its invasiveness, the minimal infective dose and the immunity of the individual.
- If infection is established, pathogens multiply in their host. Certain pathogenic bacteria are able to multiply in food or beverages, thereby perpetuating or even increasing the chances of infection. This is not the case for chemical pollutants.
- Unlike the effects caused by numerous chemical substances, the dose response of pathogens is not cumulative. A single exposure to a pathogen may be enough to cause disease.

Because of these properties, there is no tolerable lower limit for pathogens.

**Water intended for consumption, for preparing food and drink or for personal hygiene must contain no agents pathogenic for human beings.**

### Monitoring of drinking-water

It is theoretically, technically and financially impossible to detect, in drinking-water, all the pathogens capable of causing waterborne infections. There are a number of reasons why this cannot be done.

- These pathogens would be difficult to identify, on a routine basis, by all the laboratories responsible for monitoring the quality of drinking-water
- Some pathogens could not be isolated using the analytical techniques currently available
- The presence of pathogens in drinking-water is generally irregular: in order to ensure that water is totally safe, detection should be undertaken on a continuous basis, but no techniques are currently available to do this.
- Even if reliable techniques were available, the time taken to obtain the results of analyses would be far too long to ensure effective control of water quality and hence satisfactory protection of consumers.

Public health technicians have therefore had to use indirect methods to assess water contamination, such as **"marker" bacteria or indicators of faecal contamination.**

The vast majority of waterborne pathogens are of faecal origin. Monitoring must therefore be based in principle on demonstrating the presence of those organisms that are most representative of such contamination. In addition, indicators must have certain specific features: they must be non-pathogenic (or only slightly pathogenic), and they must be easily and rapidly detected at moderate cost. In addition, they must have a resistance to physical and chemical treatment (sedimentation, filtration, disinfection) similar to that of pathogens. This characteristic, in particular, will make it possible to assess the effectiveness of the various forms of water treatment applied.

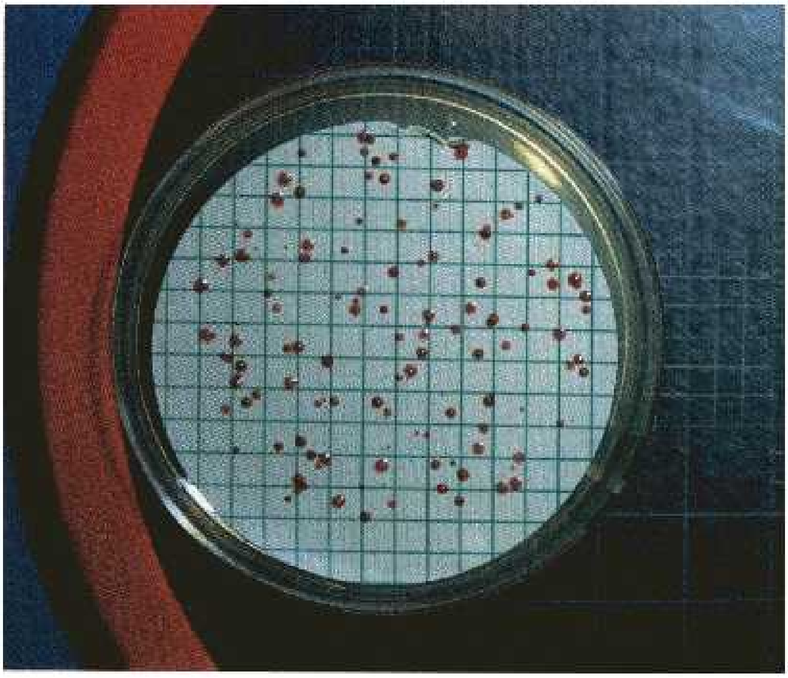
At present, thermotolerant coliform bacteria, often incorrectly referred to as faecal coliforms or *Escherichia coli*, are the generally accepted reference indicator. Other groups of organisms, such as total coliforms and sulfite-reducing *Clostridium spp*, are also used as indicators of the effectiveness of treatment.

If faecal coliforms are detected, it may be concluded that the water has been contaminated and therefore poses a potential risk. In such cases, the water will be declared substandard and unfit for drinking. Further examinations, entailing the use of special analytical techniques, may then be carried out at the initiative of the health authorities.

If no indicator organisms are found, the water may be said to meet the standards. However, there remains a slight risk that the water may be contaminated by organisms of faecal or other origin, and in particular by viruses and protozoa. According to WHO experts, this risk is extremely remote.

**Water which does not contain indicator organisms is to be regarded as fit to drink in microbiological terms.**

In recent decades, the control of infectious waterborne diseases has been (and still is in many countries) a major public health objective, requiring a range of technical measures. Among these, disinfection of water is still the most effective and commonly used method



Laboratory culture of microbes

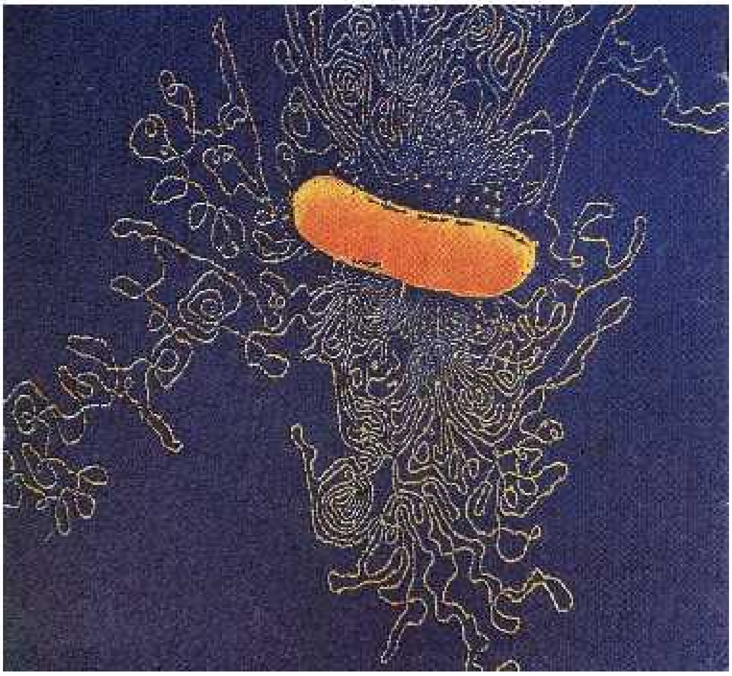
## Disinfection of water

The operation to secure protection against the risk of waterborne infection is disinfection: this treatment must be applied as a top priority when the water is contaminated or its natural potability cannot be guaranteed on a permanent basis

Water may be disinfected by various physical or chemical means

- **Boiling** To ensure full disinfection, water must be boiled for one minute at sea level. One further minute of boiling must be added for each increase in altitude of 1000 metres.
- **Ultraviolet radiation**. The effectiveness of disinfection using this technique is closely dependent on the quality of the water to be treated It must therefore be used only in very specific circumstances. In addition, it should be noted that this treatment has no residual[3] effect On the other hand, no by-products are generated.

• **Chemical procedures.** The most commonly used chemical reagents are chlorine and its compounds, ozone and chlorine dioxide. Chlorine, whether as a gas, as sodium hypochlorite (Javel water) or as calcium hypochlorite (in powdered form), is by far the oldest and most commonly used biocide[4] (for the various chlorine products, see annex).



Originally, the use of chlorine was based on the idea of a link between waterborne diseases and the bad (or "septic") smell of the water. Although it preceded discovery of the bacteria responsible for water contamination, the use of chlorine for deodorization of water proved to be very effective. This empirical discovery helped to sustain the belief that odour generated diseases. That is why the first standards for drinking-water referred to the water's organoleptic[5] characteristics: "the water shall be limpid and free from odour, taste or colour".

It was not until after 1880, through the work of scientists such as Pasteur and Escherich, that the microbiological origin of waterborne diseases was discovered and the bactericidal action of chlorine explained.

The widespread use of water chlorination in Europe has eradicated epidemics of typhoid fever and cholera in many countries.

**Disinfection by chlorine is still the best guarantee of microbiologically safe water.**

The concentration of the biocidal chemical reagent and the water/biocide contact time are the main factors which determine proper disinfection of water. The physical and chemical quality of the water to be treated must of course be taken into account when deciding on the correct concentration and contact time.

## By-products of disinfection

The injection of chlorine, a powerful oxidizing agent, into water full of organic matter gives rise to specific chemical reactions. Ammonia, iron, manganese and sulfides, in particular, react with chlorine.

As from 1974, more complex secondary reactions have been identified, in particular with some types of organic matter naturally present in water. This mainly applies to humic substances. As a result of these secondary reactions, specific chemical molecules called "organochlorines"[6] are produced. Under laboratory conditions, some of these substances have proved to be carcinogenic in animals.

Some studies have in fact shown very weak statistical associations with cancers of the stomach, large intestine, rectum or, more recently, the pancreas. The International Agency for Research on Cancer (IARC) has evaluated these studies and concluded that it cannot be stated that the consumption of chlorinated drinking-water induces cancers in human subjects.

Nonetheless, in the light of these findings, some countries have amended their regulations to take account of the long-term risks arising from by-products of disinfection.

In some cases, this has led to chlorine being replaced by other chemical disinfectants such as chlorine dioxide or ozone. Other recent work has shown that these reagents, too, lead to the formation of molecules which equally present long-term risks. The most recent edition of the *Guidelines for drinking-water quality* issued by WHO gives technical details of these chemical compounds and proposes guideline values for them.

However, all our current knowledge about secondary reactions due to chemical disinfection reagents confirms that disinfection of water remains the priority treatment in all cases.

The following objectives should therefore be adopted.

- **Give preference to naturally protected resources over dubious or vulnerable underground or surface water whose quality may require the implementation of complex treatment processes.**
- **Carry out the best possible pre-treatment, in order to eliminate as much organic matter as possible.**
- **Introduce or maintain disinfection treatment as required. Under no circumstances should the detection of by-products of chlorination lead to such treatment being reduced or, worse still, interrupted.**

## Technical aspects

Safe drinking-water may be obtained either directly from a well-protected and high-quality underground water source, or by using non-potable water that is then subjected to a series of appropriate treatments which reduce the concentration of pollutants to a level that does not entail a risk to health.

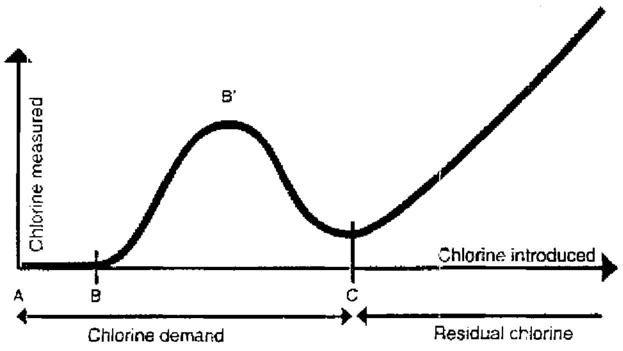
Each stage of treatment represents an obstacle to the transmission of infections. Treatment processes preceding terminal disinfection should already be capable of producing water of high microbiological quality, with terminal disinfection merely constituting the last safety barrier.

Disinfection may be used alone for limpid underground water that is well filtered by the soil.

## Behaviour of chlorine in water

When chlorine is added to water, different chemical reactions are successively produced. These mechanisms should be perfectly understood before a disinfection operation is implemented.

**Level of residual chlorine as a function of the quantity of chlorine introduced**




**Phase AB**. The chlorine introduced into the water combines immediately with organic matter. The residual amount measured therefore remains zero. Until all these compounds have been destroyed, no disinfection has occurred.

**Phase BB'**. Beyond B, the chlorine combines with nitrogenous compounds[7]. The quantity of residual chlorine may then be measured. This concentration does not correspond to genuinely active chlorine, however; instead, it is related to chloramines, which react like chlorine to the reagents used in measurement apparatus. Chloramines are complex organic products, often with a strong odour and very little disinfecting action.

**Phase B'C**. When further chlorine is added, a decreasing amount of residual chlorine is measured when the customary apparatus is used. In reality, the chlorine added has destroyed the compounds formed during phase BB'. The water smells less bad but it is still not disinfected.

**Beyond point C**, the chlorine introduced is finally available to carry out its role as a disinfectant.

In conclusion, disinfection is not ensured by the first few milligrams of chlorine introduced. Before the chlorine can really be effective, a variable quantity must be injected in order for all the secondary chemical reactions to take place. This amount is known as **the chlorine requirement.**

Disinfection must be carried out on water of good chemical quality (with a low chlorine requirement) in order to limit, so far as possible, these secondary reactions which generate by-products.

In addition, if colloidal particles[8] are present, micro-organisms are protected against the disinfecting action of chlorine.

Before initiating a disinfection process, tests should be systematically carried out to assess the quantity of chlorine that needs to be injected in order to reach past the phase of secondary reactions (see annex).

For example, it may sometimes be necessary to introduce 5 mg or 10 mg of chlorine per litre of water in order to obtain, at the end of the treatment process, 0.5 mg per litre of active chlorine, since the rest of the disinfectant will have been consumed by impurities and dissolved products.

**CASE STUDY**

**Small cause... large effect!**

*In the autumn of 1990, 800 cases of gastroenteritis (bloody diarrhoea due to the* Shigella *bacteria) occurred in three days in the eastern suburb of Le Havre (France): 30 people were immediately hospitalized. A borehole and a spring, located at the foot of a limestone plateau, were implicated. Heavy rain and failure of the chlorination equipment, which had been set to deliver a very low dose of disinfectant, had led to transient microbiological contamination of the drinking-water network by this highly virulent bacterium. Measures were immediately taken, including a ban on the consumption of water (without cutting off distribution), superchlorination and thorough flushing of the piped network. Within three days, the epidemic had been halted and the water was again declared fit for use.*

## To achieve effective disinfection

Terminal disinfection is most efficient when the water has already been treated to remove all turbidity[9] and, more particularly, all substances that can react with and "consume" chlorine. If these pre-treatment processes have not been or cannot be installed or if they fail at any time, the water can still be correctly disinfected by introducing an overdose of chlorine, but this will lead to the appearance of by-products of disinfection.

The quantity of chlorine that needs to be added to the water to achieve disinfection depends on:

- the temperature of the water;
- the contact time (time between the injection of chlorine and the moment when the water is drunk);
- the residual level of disinfectant required in the network.

Generally speaking, optimal disinfection will be achieved when the parameters set out in the box below are complied with.

**Technical parameters governing the effectiveness of disinfection**

| | |
|---|---|
| Turbidity | < 0.5 NTU[10] |
| pH | < 8.0 |
| Retention time | > 30 minutes |
| Free residual chlorine | > 0.5 mg/l |

*It is essential that the treatment preceding final disinfection produces water with a median turbidity not exceeding 1 NTU and that no single sample exceeds 5 NTU. This requirement is vital because some traditional parasites (*Giardia*, Guinea worm or *Cryptosporidium*) are not destroyed by disinfection.*

*They can only be removed by effective filtration (either naturally or by a filter installed in the treatment line).*

*The acidity or alkalinity of the water affects chlorine disinfection. Alkaline water (pH > 8) can only be effectively disinfected by superchlorination.*

*The disinfectant effect of chlorine is not immediate. There must be a minimum of 30 minutes' contact between the water and the disinfectant before the water is drunk.*

**Monitoring and maintenance of installations**

*Managers must pay constant attention to installations, and especially to the operation of disinfection equipment:*

- *inspection of the treatment plant, every day if possible;*
- *measurement of residual chlorine several times a day, after treatment and at the end of the network;*
- *maintenance of a record book detailing all the actions taken or incidents which have occurred during operation of the network.*

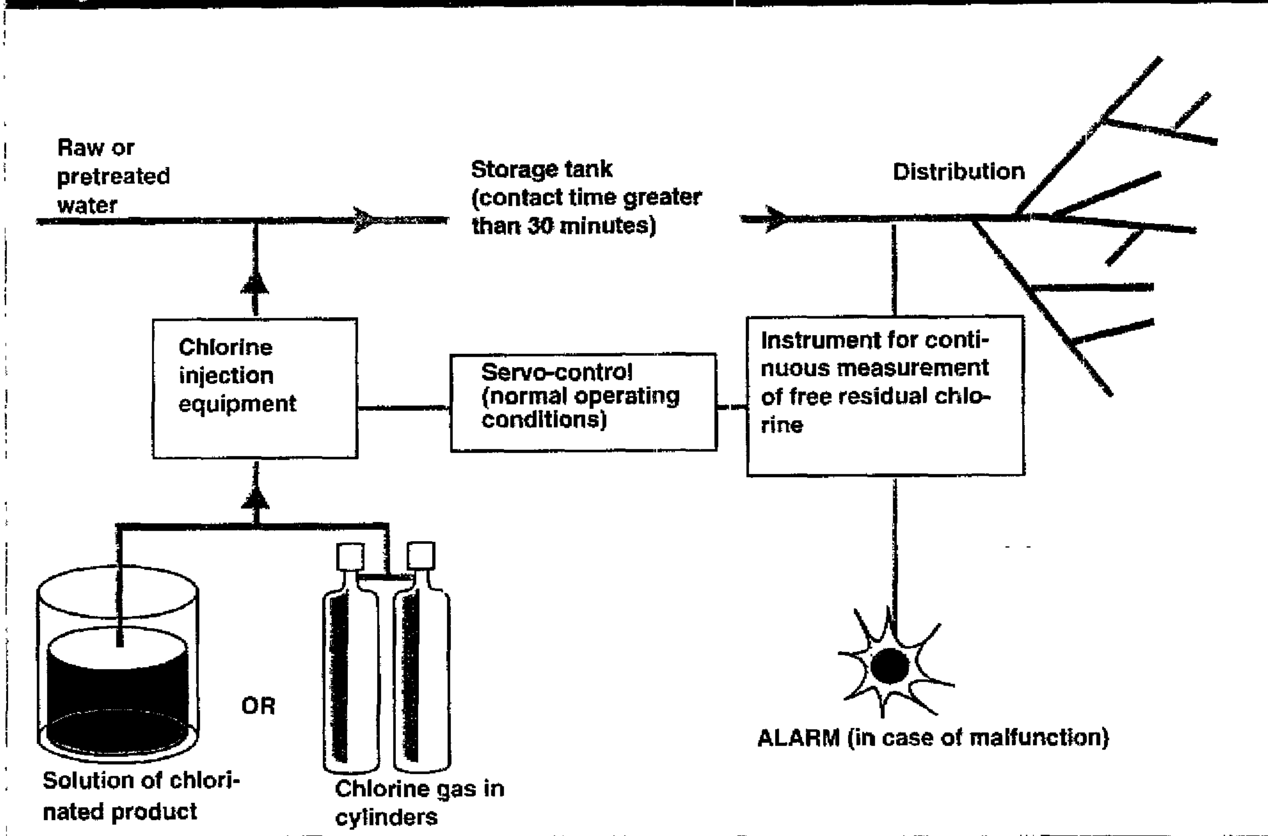
*Checks must be stepped up in exceptional circumstances, such as pollution of the water source, heavy rain, flooding, etc.*

*Monitoring of this kind must be carried out by qualified personnel trained in taking measurements and carrying out checks under field conditions.*

## Residual chlorine level

It is very important to ensure that there is free chlorine in the water at every point in the network: in addition to the weak bactericidal action imparted to water treated in this way, the fact that chlorine is found in the water proves that no organic matter which consumes chlorine has been introduced; thus it is likely that no microbes have been introduced, either, after treatment. Conversely, the abnormal lack of disinfectant in the water supply must prompt operators to take emergency measures. The level of

**Design of a disinfection system with a feedback loop linked to the level of residual chlorine**




residual chlorine is therefore an effective warning signal, providing an immediate and inexpensive way of monitoring changes in the microbiological quality of the water in the system.

The best way of ensuring that there is always a satisfactory level of residual chlorine is to make the quantity of disinfectant injected dependent on the concentration measured in the network. In some very long networks, it may be difficult to maintain a given level of residual chlorine at every point. In such situations, it may be necessary to consider splitting up the introduction of chlorine by installing chlorometers at several points in the network

## PRECAUTIONS

In order to avoid interruptions in the supply of chlorine, a spare full cylinder should always be available and, wherever possible, an automatic cylinder change-over system (manual or, preferably, automatic inverter) should be installed.

When carrying out work on pipelines, it is impossible to work under totally aseptic conditions. When the work is completed, therefore, steps must be taken to clean and disinfect the installation.

In a building, syphoning may occur if the water pressure is reduced or cut off. In order to avoid contamination, the public network can be protected by non-return valves or even disconnectors (for sites at risk).

## Regulatory aspects

Generally speaking, local authorities have no power to set quality standards. On the other hand, it is extremely important to understand the technical considerations underlying the publication of standards by central governments and to know how to interpret a laboratory analysis report.

Several aspects should be taken into account:

- microbiological quality standards for ensuring that water is not contaminated;
- standards for concentrations of disinfectant;
- standards for by-products of disinfection.

### Microbiological standards

Drinking-water must not contain pathogens. In order to ensure that the water is free from faecal contamination and that a good degree of disinfection has been achieved, indicator organisms are used: their guideline values have been specified in the WHO recommendations issued in 1993.

| Microbiological guideline values for drinking-water – WHO 1993 | |
|---|---|
| Thermotolerant coliform bacteria | 0/100 ml |
| Total coliform bacteria | 0/100 ml* |

### Standards for concentrations of disinfectant

Chlorine imparts a taste to water. The "tolerated" concentration of residual chlorine may vary widely, depending on the country and consumers' habits. In Europe, most countries limit this concentration to a very low level, of the order of 0.1 mg/l. In the United States of America and in the Americas in general, where the taste of chlorine is taken to be a guarantee of good quality water, this value is 1 mg/l.

WHO considers that a concentration of free residual chlorine in water of 0.5 mg/l after a contact time of 30 minutes guarantees satisfactory disinfection.

In addition, WHO points out that no adverse effect on health has been seen for concentrations of free chlorine up to 5 mg/l. This level has been adopted as a guideline, but it is in no way to be regarded as a level to be attained

### Standards for by-products of disinfection

The by-products of disinfection are generally represented in regulations by the trihalomethanes (THM).

In 1980, the European Communities had not envisaged any regulations on these compounds. It was merely stated that the level of THM should be as low as possible. Some countries have, however, introduced into their legislation standards governing these substances. The levels adopted vary from 25 mg/l to 100 mg/l for total THM.

WHO's guideline values concerning these substances were published in 1993. They are reproduced in the annex to this booklet WHO points out that compliance with these guideline values must not, under any circumstances, be at the expense of microbiological standards.

## Economic aspects

Epidemics of waterborne diseases can have very significant costs (for outpatient and inpatient treatment as a result of work stoppages, etc.), not to mention the social costs or the damage done to a country's image.

Water disinfection is therefore a priority treatment which pays handsomely in cost/benefit terms: the cost of disinfection is always a very small proportion of the total operating budget of a network. In general, it accounts for between 1 % and 3% of the total cost and is never more than 10 %.

On the other hand, the economic benefits of pre-treatment may justifiably be questioned.

Pre-treatment processes have many benefits, including that of ensuring a much more attractive taste and odour. The water is more acceptable and people trust it more readily. In addition, physical and chemical treatments sometimes make it possible to improve the chemical quality of the water and, above all, to achieve significant reductions in the concentrations of by-products of disinfection, as seen above. On the other hand, the cost of applying such treatments (which may sometimes be very high) is reflected in the price of the water. In some cases, it may even turn the poorest groups in a population away from using piped water, for financial reasons. Such a situation would be dangerous, because these groups might then have recourse to unsafe water and run considerable risks of contracting disease.

The balance between economic constraints and benefits for consumers is a difficult one to strike and can only be assessed in terms of the local situation. The introduction of specific treatments designed to reduce the quantity of by-products produced during disinfection must not, under any circumstances, lead to a reduction in the effectiveness of the service provided to the population as a whole.

**CASE STUDY**

**The taste of chlorine in water**

*In many countries, chlorine is thought of as a dangerous chemical product. In the United States of America, on the other hand, the taste of chlorine is seen as offering a (justified) guarantee of microbiological quality. One of the roles of managers of water supply systems is to get people to recognize this fact. A survey carried out in the east of France in the 1980s showed that, in villages where the system supplied water disinfected by chlorine (and thus with a characteristic taste and odour), consumers abandoned tap water and preferred to use water from private, uncontrolled and often contaminated wells. Conversely, in other villages where the water in the public system was not chlorinated and was therefore contaminated, consumers preferred to use tap water.*

## WHO's position

**The top priority is to ensure a continuous supply of safe water.** Disinfection is the essential and priority treatment of any water that is or may be contaminated by microbiological pathogens.

**The use of well-protected water sources should always be preferred over that of vulnerable resources requiring expensive treatment.**

**Measures to prevent a long-term risk (related to the by-products of disinfection, for instance) should not result in additional short-term risks,** such as those related to waterborne infectious diseases. Making use of other, higher quality water resources or introducing specific treatments are the only means that can be considered for reducing the quantity of by-products of disinfection.

In the light of these basic principles, WHO proposed in 1993 guideline values for a large number of disinfection by-products (see annex).

## Recommendation 1

### Ensure a continuous supply of adequate quantities of safe water.

To this end the following steps must be taken.

**• Use the highest quality resources available.**

Give preference to naturally protected underground sources over surface water. Use the latter only where underground water is not available or inadequate.

When disinfection is essential, give preference to the use of water with good physical and chemical characteristics.

**• Consider all available ways of protecting water sources.**

Give priority to protection of the source over the introduction of complex treatments.

Regardless of where the water comes from, introduce water source protection measures, in the form of protection zones for underground water sources (see *Protection of water sources* in the same series).

Ensure surveillance of protection zones and monitor the quality of the water resource. The more constant the quality of water before it is treated, the easier it is to disinfect it.

**• Ensure effective and continuous disinfection of water.**

Make sure that the pre-treatments used are appropriate for correct terminal disinfection.
Give preference to disinfection treatments which offer the highest level of safety.

Ensure that the treatments used, especially for disinfection, are reliable. Wherever possible, the quantity of chlorine injected should be coupled to the flow of water to be treated.

Ensure that there is always free residual chlorine present at every point in the network.

Check and regularly maintain all components of the water supply system: extraction plant, treatment equipment, storage facilities and supply networks.

## Recommendation 2

### Ensure public information and community participation.

Ensure that the population has confidence in the quality of the public piped water supply. Suspicions concerning quality may make consumers turn to alternative sources that are contaminated or not controlled.

Inform consumers about the quality of water supplied.

Recall the public health benefits of water disinfection.

## Useful address

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