

# Disinfection as a water treatment process

## What is disinfection?

Disinfection of drinking water is the treatment process used to destroy or inactivate disease-causing micro-organisms, or pathogens, present in the water supply and thereby ensure the provision of a safe drinking water.

## The importance of providing safe drinking water

Safe drinking water is one of mankind's most important basic needs. Water is a source of life but can also be a source of destruction if it contains pathogens. This is especially the case in South Africa where a high proportion of immunocompromised individuals exists.

**Access to safe drinking water is a basic human right and essential to people's health!**



## The multi-barrier approach to ensuring safe drinking water

The key to ensuring clean, safe and reliable drinking water is to use multiple barriers to control microbiological pathogens and contaminants that may enter the water supply system. The approach recognizes that while individual barriers may be inadequate in effectively removing or preventing contamination, together they provide greater assurance that the water will be safe to drink. A multi-barrier approach includes:

- ❖ Barrier 1: Selection of the best available source (e.g., river, groundwater) and protecting it from contamination;
- ❖ Barrier 2: Effective water treatment, including disinfection, and
- ❖ Barrier 3: Prevention of water quality deterioration in the distribution system.

## The role of disinfection in ensuring safe drinking water

A consumer cannot tell if drinking water is free of pathogens by normal inspection. Therefore, the main purpose of disinfection is to reduce the potential health risk associated with consumption of drinking water by inactivating pathogens. This prevents the possible spread of water-borne diseases. The safety of drinking water is determined by testing for indicator organisms, as shown in Table 1.

**Primary disinfection** refers to the initial inactivation of pathogens in source water. **Secondary disinfection** refers to the maintenance of disinfection residual which prevents the reoccurrence of contamination during distribution and storage.

**Table 1: Common indicator micro-organisms**

Indicator	Detection and use in drinking water quality management
Standard Plate Count/ Heterotropic Plate Count	Used for monitoring of efficiency of water treatment and disinfection process, and aftergrowth in water distribution systems.
Total Coliform bacteria	Used to evaluate the general sanitary quality of drinking water
Feacal Coliform bacteria	Indicator of probable feacal pollution of drinking water.
Escherichia coli ( <i>E. coli</i> )	Indicator of feacal pollution of drinking water.

### How is disinfection practiced?

Micro-organisms can be destroyed/ inactivated by various physical and chemical methods.

#### ❖ Physical Methods

Physical methods of disinfection include ultraviolet (UV) radiation, heating, freezing and ionization. Of these only UV is practicable for drinking water supply purposes.

UV radiation is a good biocide but provides no persistent residual for distribution protection; **hence a secondary disinfectant must be used to prevent contamination within the distribution network.** UV disinfection is generally more practical for small capacity plants because of the capital and operating expense necessary to ensure adequate water contact with lamp surfaces for large capacity plants.

#### ❖ Chemical Methods

Chemical methods depend mostly on selected chemicals with oxidizing and biocidal properties. The most commonly used drinking water disinfection chemicals include ozone and chlorine.

Ozone is the most powerful disinfectant and oxidant used in drinking water treatment. **A secondary disinfectant, usually chlorine, is required because ozone does not maintain an adequate residual in water.**

Chlorine and its compounds (e.g. calcium hypochloride, sodium hypochloride, chlorine dioxide) have been historically the most popular chemical disinfection agents.

Free chlorine is an excellent biocide and provides a persistent residual to maintain the microbiological safety of the finished water as it passes through the distribution system.

Chloramines are chlorine compounds formed by addition of ammonia and chlorine, and have an advantage of having a long half-life, and are exclusively used in very long distribution networks.

**Residual disinfectant** is the level of disinfectant that remains in treated water to ensure disinfection protection and reduce the risk of recontamination throughout the distribution system (i.e. pipes).

The advantages and disadvantages of the most commonly used disinfectants are summarized briefly in Table 2.

**Table 2: Advantages and disadvantages of most commonly used disinfection methods for water supply**

<b>CHLORINATION</b>	
<b>Advantages</b>	<b>Disadvantages</b>
<ul style="list-style-type: none"> <li>❖ Very effective; has a proven history of protection against water-related disease</li> <li>❖ Provides residual disinfectant</li> <li>❖ Residual easy to measure</li> <li>❖ Chlorine readily available at reasonable cost</li> <li>❖ Low electrical requirement</li> <li>❖ Can be used for multiple water problems (bacteria, iron etc.)</li> <li>❖ Appropriate as both primary and secondary disinfectant</li> </ul>	<ul style="list-style-type: none"> <li>❖ Requires contact time of 30 minutes for simple chlorination</li> <li>❖ Turbidity (cloudy water) can reduce the effectiveness of chlorine</li> <li>❖ Gives water a chlorine taste</li> <li>❖ Does not kill <i>Giardia</i> cysts at low levels</li> <li>❖ Careful storage and handling of gaseous chlorine is required</li> </ul>
<b>ULTRAVIOLET LIGHT</b>	
<b>Advantages</b>	<b>Disadvantages</b>
<ul style="list-style-type: none"> <li>❖ Does not change taste or odour of water</li> <li>❖ Kills bacteria and viruses almost immediately</li> <li>❖ Simple operation and maintenance for high quality waters</li> </ul>	<ul style="list-style-type: none"> <li>❖ Relatively high cost</li> <li>❖ High electrical demand</li> <li>❖ Requires a secondary disinfectant, as no disinfection residual</li> <li>❖ Requires pre-treatment of surface water</li> <li>❖ Requires frequent cleaning and new lamp annually</li> </ul>
<b>OZONE</b>	
<b>Advantages</b>	<b>Disadvantages</b>
<ul style="list-style-type: none"> <li>❖ Very effective and strong oxidant</li> <li>❖ Effective against <i>Giardia</i> and <i>Cryptosporidium</i></li> </ul>	<ul style="list-style-type: none"> <li>❖ Relatively high cost</li> <li>❖ More complex operations and maintenance, as must be generated on-site</li> <li>❖ Requires a secondary disinfectant, as does not maintain adequate disinfection residual</li> </ul>



## Why disinfection ?

Water-borne diseases, such as typhoid, cholera, dysentery and gastro-enteritis have killed more people than all the wars in history. For example, according to the World Health Organisation (WHO) "*3.4 million people in developing countries, most of them children, die every year from diseases associated with lack of safe drinking water, inadequate sanitation and poor hygiene*". Disinfection plays a crucial role in ensuring the safety of your drinking water.

**Groundwater**, although filtered by natural processes, is often susceptible to microbial contamination. Furthermore, this water may be contaminated during distribution and or in the home. A surprisingly high incidence of microbiological contamination has been observed in systems based on groundwater sources. Accordingly, groundwater should always be disinfected prior to distribution.

## Chlorine disinfection

Chlorination is the most commonly practiced disinfection method throughout the world, with the important advantage of providing a residual disinfection capability keeping drinking water safe right up to the tap. According to the World Health Organization, the adoption of drinking water chlorination has been one of modern society's most significant advances in public health protection. Chlorination is therefore discussed further in more detail.

Factors influencing chlorination disinfection include:

- ❖ Concentration of free chlorine residual – the effectiveness of chlorination is directly linked to the concentration of free available chlorine and the contact time. If the free chlorine residual is reduced, then the contact time must be increased.
- ❖ Contact time – length of time the organisms are in physical contact with the chlorine.
- ❖ Turbidity – affects disinfection efficiency when suspended particles shield bacteria from the disinfectant. Ideally, turbidity should be approximately 1 NTU to ensure optimum disinfection.
- ❖ Water temperature - chlorine reacts much faster in warm water than in colder water (temperature should be 12°C and above).
- ❖ pH - the lower the pH, the more effective the disinfection. Chlorination works best with a pH below 8.0.

## Chlorination monitoring

Where chlorine is used for disinfection, the free chlorine residual should be monitored at least daily. Samples should be taken at various locations throughout the water distribution system, including the furthest points. Most small water supply systems will use a quick and simple, yet effective test, called the DPD colorimetric test.

## Chlorine storage and supply

Chlorine for use by Water Services Authorities is most commonly supplied as liquefied gas under high pressure in containers varying in size from



68 kg to 909 kg. An example of pressurized chlorine gas cylinders is shown in Figure 1 below.



Figure 1: Pressurised chlorine gas cylinders

Safety considerations of chlorine storage and supply include:

- ❖ Chlorine storage and chlorinator equipment must be housed in a separate building. If not, it should be accessible from an outside door.
- ❖ Adequate ventilation at floor level should be provided because chlorine gas is heavier than air. Fan control and gas masks should be located at room entrance.
- ❖ The temperature in the chlorine supply area should not be allowed to drop below 10°C.
- ❖ Storage should be provided for at least a 30 day supply.

### Chlorine dosing equipment

Chlorine can be abstracted directly from the gas phase of the pressurized container with chlorinator. The most widely used chlorinators are those using vacuum-feed devices. In each of these systems, the chlorine injector is the basic component. The injector is used to create the

vacuum that is used to draw the chlorine gas from the storage supply through the chlorine regulator, which serves as metering device, and into the injector. At the injector, the chlorine dissolves in the injector water to form hypochlorous acid. From the injector, the hypochlorous acid solution flows to the point where it is to be injected into the clarified water. This process is shown in Figure 2 below.



Figure 2: Process equipment for chlorine gas injection into water

Drinking water chlorination has contributed globally to a dramatic decline in water-related disease rates and increased life expectancy. In recent years a concern has developed to the possible health impacts of **disinfection byproducts** (DBPs), created during disinfection. The health risks from these byproducts at the levels at which they occur in drinking water are extremely small in comparison with the risks associated with inadequate disinfection. **Thus, it is vital that effective disinfection not be compromised by attempts to control disinfection byproducts.**



### How can a Water Services Authority tell if their water is properly disinfected?

The safety of drinking water can not be determined by human senses alone. A water that looks safe, smells safe, and tastes safe may be contaminated with pathogens. For this reason your Water Services Authority regularly checks the disinfection efficiency of your drinking water as follows:

- ❖ Sampling and analysis of the drinking water for microbiological indicators of water quality

and contamination (for example, total coliforms, faecal coliforms, and E. coli) to confirm effective disinfection.

- ❖ Sampling and analysis for free chlorine residual and turbidity to optimize disinfection efficiency – **NOTE: In the absence of microbiological tests, a free chlorine residual (target range of 0.2 mg/L to 0.5 mg/L) in a water with low turbidity (< 1 NTU) indicates a drinking water that is safe to drink.**

### ADDITIONAL INFORMATION

If you would like more information about disinfection as a part of the water treatment process, you can get it from:

- ❖ The Department of Water Affairs and Forestry: Additional information on drinking water quality treatment and management can be found in the Department of Water Affairs and Forestry, Department of Health and Water Research Commission guides on the **Quality of Domestic Water Supplies** (<http://www.dwaf.gov.za/iwqs/report.htm>).
- ❖ The Department of Water Affairs and Forestry - Water Services Regulation (012) 336 6583 / 6870 / 6871, or your Regional Department of Water Affairs and Forestry office:
  - Northern Cape (053) 830 8800
  - Western Cape (021) 950 7100
  - Eastern Cape (043) 604 5400
  - Gauteng (012) 392 1300
  - North West (018) 384 3270
  - Limpopo (015) 290 1200
  - Mpumalanga (013) 759 7300
  - Kwa-Zulu Natal (031) 336 2700
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