Point-of-Use Chlorination

Response Phase	Application Level	Management Level	Objectives / Key Features
** Acute Response ** Stabilisation ** Recovery	** Household Neighbourhood City	** Household Shared Public	Point-of-use treatment, water disinfection
Local Availability	**Technical Complexity**	**Maturity Level**	
*** High	* Low	*** High	

Chlorination is a relatively quick, inexpensive and simple household disinfection method. Adding chlorine or chlorine compounds in either liquid form or tablets/powder to water effectively inactivates microorganisms. Sufficient chlorine levels can provide residual protection from recontamination.

Chlorine effectively inactivates microorganisms, and in sufficient quantities, the residual chlorine inhibits microbial re-growth and protects against recontamination. However, chlorine is ineffective against microorganisms with strong cell walls, such as Cryptosporidium oocysts and some bacterial spores at concentrations and contact times used for water treatment. Chlorine, as well as other chemical disinfectants such as bromine, iodine and peroxide, inactivate microorganisms by oxidising their biochemical building blocks, thus disrupting vital cell functions. The efficiency of chemical disinfectants depends on how reactive they are against specific microorganisms and their concentration, contact time and water quality characteristics, such as pH, oxidant demand and temperature. Chlorine reacts rapidly with (in)organic compounds in water, which exerts a demand on the chlorine, thus influencing the concentration available for microbial disinfection. Turbidity can shield microorganisms and reduce the effectiveness, so turbid water should be treated beforehand.

Design Considerations: All forms of chlorine-containing products for household use are designed for the treatment of 1–20 L of water using a small volume of chlorine (e.g. 2–5 mL per 20 L of water, or 1 tablet for 1.5–20 L of water), allowing users to treat multiple unit volumes. Usually, the user needs only to measure out the liquid or dispense the tablet, add it to the water, mix briefly and allow for the appropriate contact time as defined by the manufacturer (normally 30 min). Usually, the chlorine dose is proposed by manufacturers to assure at least 0.5 mg/L of residual chlorine concentration in treated water to protect from recontamination. For emergencies with normal or low risk of disease outbreaks, the recommended free chlorine resid-

ual should be 0.2–0.5 mg/L. In reality, concentrations vary widely depending on water quality, temperature, quality and age of chlorine-containing products. If the chlorine is under-dosed, the microorganisms may not be destroyed, and if overdosed, the taste and odour may be affected. For Chlorination to work effectively, the turbidity of the source water should be less than 5 NTU. For higher turbidity spikes, some pathogens may not be inactivated. Low temperature (under 20° C) and high pH (> 8) also affect the Chlorination process, and here the residual chlorine and/or the contact time need to be increased.

Materials: Chlorine exists in different forms with differing percentages of active chlorine. In emergencies, the most used products for household treatment are sodium diisocyanurate (solid tablets also known as NaDCC) or sodium hypochlorite solution. Liquid chlorine can be locally or regionally produced and distributed in bottles that treat hundreds to thousands of litres before a repeat purchase is necessary. Chlorine tablets can be purchased in individual or multiple units (bottles and blister packs) and require regular or periodic repeat purchases or distribution. NaDCC tablets can be shipped by air without restrictions, while other forms of chlorine need to be shipped as hazardous materials.

Applicability: Disinfection using chlorine is relatively quick, simple and inexpensive. Chemical disinfectants are appropriate for places where water is bacterially contaminated and not very turbid. Chlorination has proved to be efficient in acute emergency situations and as a response to cholera epidemics **(see X.14)**. In locations also affected by chemical contaminants or very high turbidity and natural organic matter content, Chlorination should be used along with other treatments, such as Ceramic Filtration **(H.3)**, Coagulation, Sedimentation and Chlorination **(H.8)**, or Fluoride and Arsenic Removal Filter **(H.13, H.14)**.

Operation and Maintenance: Disinfection with chlorine can be easily learned and must be carried out regularly. Apart from cleaning and the occasional replacement of containers and utensils, no maintenance is needed. However, Chlorination requires a constant supply of consumables that users must be able to purchase regularly, or distribution must be organised frequently. Chlorine may degrade over time and if improperly stored. Liquid and solid chlorine should always be stored away from direct sunlight, excessive humidity and high or varying temperatures. Open packages should be used quickly, and the information regarding the shelf-life provided by the manufacturer must be respected. When water is turbid (> 5 NTU), it will need to be pre-treated, such as by filtering or coagulation **(see H.3 or H.8)** to remove particulate matter. A pH > 8 reduces the efficiency of Chlorination, and when pre-treatment is not yet in place, higher concentrations and longer contact times can be applied to counter this in the short term.

Health and Safety: Chlorination at concentrations used for drinking water treatment is very efficient at inactivating bacteria, less efficient against viruses and not efficient against some protozoa. Turbidity is an issue, as particles in the water may shield microorganisms from disinfection. High organic matter content leads to the formation of disinfection by-products (DBPs) that should be minimised due to the potential health concerns associated with their long-term exposure. However, the long-term potential risks to health from these by-products are low in comparison with the confirmed acute risks associated with inadequate disinfection, and disinfection should therefore not be compromised in attempting to control DBPs in the acute phase of an emergency. Chlorine products have to be handled carefully and kept away from children, as they can irritate the skin, eyes and respiratory system. Continuity of product supply and extensive education to ensure correct use are essential. Provided safety data sheets for chlorine-containing products should be consulted for safety and protection requirements.

Costs: Chlorination is a cheap water disinfectant with costs of around 0.1–0.5 USD per 1000 L for liquid chlorine solutions or 1.5 USD per 1000 L for tablets. However, if locally produced chlorine is not available, transport and logistics may increase the price considerably. Some countries have regulations limiting import of chlorine-containing chemicals.

Social and Environmental Considerations: Some users may be reluctant to chlorinate due to its impact on the taste and odour of the water. User scepticism about effectiveness might be supported by the unchanged appearance of water. The distribution of chlorine needs complementary hygiene promotion measures **(see X.16)** to ensure proper use and to avoid under or over-dosing.

Strengths and Weaknesses:

- ⊕ Is easy to apply, inexpensive and reliable for inactivating bacteria and viruses if water is not too turbid
- ⊕ Provides residual chlorine for avoiding possible recontamination
- ⊕ Available in different countries

- ⊖ Requires regular supply of chlorine
- ⊖ Taste may not be acceptable to some users
- ⊖ Requires water with low turbidity to be most effective
- ⊖ Not effective against some protozoa
- ⊖ Effectiveness depends on various factors like temperature, sanitary conditions and pH

→ **References and further reading material for this technology can be found on page 222**