CIWEM Chartered Institution of Water and Environmental Management

Policy Position Statement

Chlorine disinfection of water supplies in the UK

Purpose

This Policy Position Statement (PPS) outlines the basis for using chlorine as a disinfectant for water supplies within the UK. It considers the history of waterborne disease, the subsequent legislation requiring utilities to disinfect drinking water, the maintenance of good operational practices by water supply utilities with regard to the requirements of regulators and the risk to public health.

This PPS should be read in conjunction with CIWEM's PPSs on 'Disinfection of water supplies' and 'Ultraviolet (UV) disinfection of drinking water supplies'[1].

CIWEM's Position on Chlorine Disinfection:

CIWEM believes that drinking water from untreated sources that may be, or are contaminated by, harmful micro-organisms presents an unacceptable risk of disease and is a danger to public health. Chlorine provides a safe means of providing disinfection.

Following treatment, chlorine remains in the water in the form of a residual which provides protection against recontamination in distribution. This residual continues to perform a disinfecting role thereby providing significant protection on route to the customer's tap. Other forms of disinfection are important but CIWEM considers it safest to drink water from supplies where disinfection has included a chlorine residual according to current practice and guidelines.

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Context

Urban development brought about the requirement in towns and cities for centralised systems for the provision of drinking water through piped supplies. In the past, these drinking water supplies were often contaminated by ingress of sewage and animal wastes that caused waterborne disease outbreaks.

Since the pioneering work of John Snow in the 1850s firmly established a link between cholera and contaminated water supplies, proper treatment and supply has been seen as crucial for providing safe drinking water. Robert Koch in Germany subsequently demonstrated the

[1] These are available from: http://www.ciwem.org/policy/processed-water/

effectiveness of filtration as a means of disinfecting drinking water although its benefits were already known from anecdotal observation in Scotland.

Despite this improvement, it was the introduction of chlorine as a chemical disinfectant around the turn of the 20th Century that brought about a considerable reduction in the burden of infectious waterborne disease. One of its first reported uses was for the disinfection of water supplies in 1897, when bleach solution was used to disinfect a water main in Maidstone following an outbreak of typhoid. The first continuous application is accepted to be in 1902 at Middelkerke, Belgium and, subsequently, was rapidly adopted worldwide as an effective means of disinfection.

Since then, chlorine is now the most widely used disinfectant for inactivating pathogens during preparation of drinking water at a treatment works and is present as a residual, sometimes in combination with ammonia, to preserve drinking water quality during distribution to customers. Its introduction has been viewed as one of the major advances in public health protection in history. It is not without its disadvantages, however, and concerns exist over the potential adverse health effects formed by its reaction with various substances to form disinfection by-products.

On balance, it is generally accepted that chlorination is an essential component of providing microbiological safe drinking water but it must be used properly to minimise the production of potentially harmful by-products.

Key Issues

Why is chlorination carried out?

1. The primary reason for using chlorine is to protect public health by inactivating pathogenic viruses and bacteria that may be present in some sources of drinking water. It is not sufficiently effective, however, against parasitic protozoa, such as *Cryptosporidium* and *Giardia*, at the concentrations typically applied during water treatment. Instead, these organisms are dealt with by removal processes during the earlier stages of treatment, membrane filtration or by UV disinfection.
2. In the UK there is a legal requirement (monitored by water companies and drinking water quality regulators) to disinfect public water only up to the point of supply. It is universal practice, however, for drinking water to be supplied with a residual to preserve its quality during distribution.
3. Water companies are obliged to produce a disinfection policy for each of their water treatment works.
4. Chlorine is relatively low cost compared to alternative disinfectants, and it is a powerful and rapid acting disinfectant.
5. The operational use of chlorine in gas or liquid form is widespread and well documented, having a good safety record. There are many delivery, dosing, control and monitoring technologies and systems available.

6. The addition of chlorine does not present a recognisable health hazard at the chlorine concentrations used within water supplies in the UK, although it is acknowledged that some customers may dislike a chlorinous taste or odour.

What does chlorination do?

7. Disinfection is not equivalent to sterilisation and cannot be construed as ensuring the complete inactivation of all pathogenic organisms (i.e. those able to cause infectious intestinal illness in humans). However most organisms are effectively reduced to a level that poses a negligible risk to public health.

8. Organisms can be shielded by particulate material in some sources of drinking water and chlorination, therefore, should be linked to achieving a low water turbidity prior to its application. This may require pre-treatment processes if source waters are turbid, e.g. coagulation, flocculation, sedimentation, filtration and these are typical of those applied to water in the UK.

How does chlorination work?

9. Chlorine species dissociate in solution to form free chlorine. The proportion of chlorine in its strongest form (hypochlorous acid) is greatest at acidic pH, i.e. disinfection is more efficient at a lower pH value, if all else is kept equal. Chlorine can also combine with ammonia to form chloramines and organic substances to form combined chlorine compounds; these types of compounds are less powerful than free (available) chlorine for disinfection. Total chlorine represents the sum total of all the chlorine species in solution.

10. The 'Ct' value represents the chlorination requirement to achieve a defined level of inactivation for a particular organism. It is the product of the chlorination concentration (mg/l) and period of contact (minutes) and expressed in units of mg·min/l. The necessary Ct value to achieve sufficient disinfection will vary depending on the pH and temperature of the water and allowance is made for their impact on chlorination. For practical applications in water treatment, it is assumed that for a given Ct, the relationship between chlorine concentration and time is a constant, i.e. higher concentrations and lower contact times are equivalent to lower concentrations and longer contact periods.

11. Guidance from the World Health Organisation[i] has stated that adequate disinfection by chlorination can be achieved by applying a dose to provide a residual of at least 0.5 mg/l for 30 minutes contact time at a pH below 8. The applied dose to achieve this level of residual will be higher than this and depend on the quality of the water being treated.

Why is there chlorine in a distribution system?

12. A chlorine residual in distribution is used to preserve the microbiological quality of drinking water during supply and provide some protection in the event of ingress of pathogens.

13. The free (available) chlorine residual applied to drinking leaving a water treatment works continues to react in distribution and its concentration decreases during transit. The rate

and extent of its decay depends on a number of factors including the amount of organic substances, the interaction between chlorine and pipe materials, and water temperature. Occasionally additional chlorine (booster chlorination) may be added. This is done where losses are too great to maintain an effective residual in distribution systems and is most common where water distribution system has a high residence time.

14. As an alternative to free (available) chlorine, some water supplies use monochloramine as a residual. It is less powerful as a disinfectant but is also less reactive with interfering substances and so can persist further in a distribution system.

15. Monochloramine is typically formed by adding ammonia to drinking water disinfected with free (available) chlorine, or by the addition of pre-formed chloramines. It is important that sufficient ammonia is added to maximise the formation of monochloramine. An excess of ammonia, however, can lead to nitrification in the distribution system which can rapidly cause the decay of the monochloramine residual.

16. Precautions need to be taken to ensure that dialysis patients and fish-keepers are aware that their supply contains a monochloramine residual to avoid any adverse effects.

17. In some countries, biologically stable drinking water can be achieved without a disinfectant residual. These types of water supply have naturally low concentrations of nutrients that are capable of supporting microbial growth or have been extensively treated to remove the nutrient sources.

What is the concern with chlorination?

18. The reaction between chlorine and certain types of organic substances naturally present in some sources of drinking water can lead to the formation of potentially harmful disinfectant by-products (DBPs), such as trihalomethanes.

19. Water companies have a legal requirement to ensure that water treatment minimises the formation of disinfectant by-products whilst at the same time not compromising disinfection. Certain DBPs are regulated and must not exceed specific concentrations during supply.

20. There may be adverse health effects if sufficiently high concentrations of chlorinated organics (e.g. such as chloroform) are ingested over a long period of time (e.g. lifetime exposure). Toxicological data suggests that under current UK practice (e.g. with treatment processes minimising dissolved organics), this risk is minimal compared to the high probability of illness - or even death - caused by drinking untreated water that contains microbial pathogens.

Conclusion - the future of Chlorine Disinfection within the UK

For over a hundred years, chlorination of drinking water has proven to be a very effective barrier against the transmission of waterborne disease and has a long history of safe and effective use for water treatment and preserving its microbiological quality during supply to customers.

In the short to medium term, it is likely that chlorination will remain an important treatment process. Water companies, public health professionals, researchers and regulators, however, continually evaluate current toxicological and process technology information to reduce the risks as much as practicable from exposure to disinfection by-products.

Exclusions

This PPS is aimed at current practices within England, Scotland, Wales and Northern Ireland using chlorine gas or solutions as a primary disinfection process in an approved treatment process train or system. It does not discuss chlorine dioxide processes although such treatment is sometimes applied as a secondary treatment for water distributed in large buildings with complex plumbing installations,

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Note: CIWEM Policy Position Statements (PPS) represents the Institution's views on issues at a particular point in time. It is accepted that situations change as research provides new evidence. It should be understood, therefore, that CIWEM PPS's are under constant review that previously held views may alter and lead to revised PPS's. PPSs are produced as a consensus report and do not represent the view of individual members of CIWEM.