PROTECTING PUBLIC HEALTH: WATER CHLORINATION

SAFE DRINKING WATER

Probably one of the most widely recognised uses of chlorine in everyday life is disinfection of drinking water. Chlorine was first used to make water safe in the late 19th century. At that time, it proved invaluable to control the spread of water-borne diseases such as typhoid, cholera, dysentery and gastro-enteritis.

Fighting such diseases, which have killed more people than all the wars in history, remains vital today. 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."

A powerful disinfection agent, elemental chlorine and its derivatives, sodium hypochlorite and chorine dioxide, quickly kill bacteria and other micro-organisms when added to water in minute quantities. Chlorine has the major advantage of ensuring clean water right to the tap, whereas the action of other disinfection techniques - such as ozone, ultraviolet light and ultrafiltration - is much more temporary. In addition to purifying water, chlorine not only helps to remove unpleasant tastes or odours, but also helps eliminate unwanted nitrogenous contaminants, and control the growth of slime and algae in distribution pipes and storage tanks.

The use of chlorine or its derivatives for disinfection of drinking water has to fulfil these key requirements:

1 – Ensure good microbiological quality and endurance of disinfection (no pathogens).[1]
2 – Minimise the level of residual chlorine, which affects taste.
3 – Minimise the formation of by-products without compromising microbial safety.

Today, most of Western Europe's drinking water is made safe with the help of chlorine. It is an essential part of the purification processes used by water companies to supply our homes, industry and ensure that discharges of wastewater to rivers and seas are safe.

CHLORINATION MILESTONES[2]

1774	Swedish pharmacist Carl W. Scheele discovered chlorine.
1897	Chlorine bleach (a solution of sodium hypochlorite) was used to disinfect a water main in Maidstone, UK, following an outbreak of typhoid.
1905	In Lincoln, UK, first known regular use (of sodium hypochlorite) after a typhoid epidemic.
1908	In Chicago George A. Johnson initiated chlorination in the USA by using "chloride of lime" to decontaminate river water.
1910-20	Introduction of effective techniques for storage and transportation of liquid chlorine; development of equipment to chlorinate water.

[1] FIFE-AISE: Benefits and Safety Aspects of Hypochlorite formulated in Domestic Products, Support Dossier, Ch. 2.4. - page 15.
[2] IARC Monographs Vol. 52 - 1991.

1950s Introduction of corrosion and break-resistant PVC (polyvinyl chloride) pipe, which is made from chlorine, for water distribution systems.

PROTECTING SWIMMERS…AND THE ENVIRONMENT

Apart from drinking water, chlorine is used to sterilise water in private and public swimming pools and to disinfect and deodorise the throughput in waste water treatment plants.

In public pools, regular and proper use of a chlorine disinfectant kills bacteria, viruses and other disease-causing microbes, thus preventing the transmission of diseases such as athlete's foot, ear infections, dermatitis and bacterial gastro-enteritis. The typical chlorine smell is caused when it destroys organic contaminants such as sweat, saliva, hairs and even urine from swimmers. For ease of handling, private pool owners mostly use sodium hypochlorite solution or tablets of dry calcium hypochlorite for disinfecting the water.

In water treatment plants, chlorine can play two roles. Firstly, when added to the water as it enters the plant, chlorine assists in the retention of active bacteria within the process cycle by enhancing their settling ability. Secondly, chlorine added to the processed water prior to discharge to river or sea provides a final sterilisation and deodorisation boost to ensure it is safe from microbial contamination. This is often used by water treatment plants that discharge treated water upstream from recreational bathing sites or seafood farming areas.

DISINFECTION BY-PRODUCTS

During the water treatment process, chlorine reacts with organic matter such as decomposing leaves or soil to create what are called disinfection by-products (DBPs). The most common class of DBPs is trihalomethanes (THMs). Toxicological studies suggested that some THMs are carcinogenic to laboratory animals, but only at levels many thousands of times greater than those found in drinking water. Recent studies on chloroform (the main type of THMs) show that it is unlikely to cause cancer at the extremely low levels found in drinking water.

In addition to concerns about carcinogenicity attention has also focused on possible relationships between DBPs and adverse reproductive and developmental effects. Overall however, evidence for such effects are sparse and the findings inconsistent.

Based on available research, WHO concluded that the "risks to health from DBPs are extremely small in comparison with inadequate disinfection" and urged that disinfection not be compromised in attempts to control DBPs (N.B. In 1993, WHO issued *Guidelines for drinking water quality.* This sets values for various DBPs on the basis of a single excess case of cancer in a given large population of people each drinking two litres of water per day for 70 years).

Chlorine disinfection in the EU is regulated by the 1998 Drinking Water Directive, which includes limits on DBPs.

It is essential to remember that the primary purpose of chlorination is the protection of public health and that any minimal or hypothetical adverse effects have to be balanced against the benefits gained from chlorination. This is well illustrated by the tragic consequences of a misinterpretation of US Regulations in 1991 by the Peruvian Government that led to suspension of the chlorination of that country's water supplies. The resulting cholera epidemic, which also spread to neighbouring countries in Latin America, caused about 800,000 cases of cholera and more than 6,000 deaths.

OTHER WATER DISINFECTION TECHNIQUES

There are other processes designed to purify drinking water, such as ozone, ultraviolet irradiation, and ultrafiltration. However, the principal advantage over alternative disinfection processes is that chlorination is the only method that persists long enough to keep water germ-free right up to the tap. Pathogens can easily enter the distribution system downstream of a water treatment plant - especially in older or poorly-maintained pipeline networks. Chlorine also prevents the growth of biofilm (for example: algae in pipes and slime formation in storage tanks). Another distinct advantage is that it can be used with relatively simple techniques and at low costs, which makes chlorination a particularly appropriate disinfection technique for lesser-developed countries.

CONCLUSION

Chlorination has a long-term track record as a safe and powerful technique for ensuring acceptable safety standards of drinking water worldwide. Since all disinfection methods produce by-products, the choice is always a question of finding the right balance between advantages and disadvantages in particular circumstances. Nevertheless it should be recognised that the public health risks of waterborne pathogens substantially outweighs the potential, but extremely small risks of DBPs at current application levels.

Chlorine is effective against all types of microbes, including bacteria, viruses, moulds and spores, easy to use, low cost and widely available. Chlorine has been used for more than a century to disinfect water and with a burgeoning world population will continue to play an essential role in protecting public health during the 21st century.

FURTHER INFORMATION:

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KEY SCIENCE INFORMATION SHEET
One of a series Euro Chlor is publishing to improve understanding by non-scientists of scientific issues. Each publication focuses on health or environmental aspects of the production, use and disposal of chlorine and its derivatives. *Protecting public health: water chlorination* can be found on the Internet at C*hlorine Online* (http://www.eurochlor.org) where subsequent information sheets will be posted as and when they become available.

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