Drinking Water Chlorination: Practices and Issues

The widespread treatment and distribution of public drinking water supplies is one of the greatest achievements of the twentieth century. Before cities began routinely treating drinking water with chlorine (starting with Jersey City in 1908), cholera, typhoid fever, dysentery and hepatitis A killed thousands of U.S. residents annually. Drinking water chlorination and filtration have helped to virtually eliminate these diseases in the U.S. and other developed countries.

Meeting the goal of clean, safe drinking water requires a multi-step approach that includes: protecting source water from contamination, appropriately treating raw water, and helping ensure safe distribution of treated water to consumers' taps.

During the treatment process, chlorine is added to drinking water as elemental chlorine (chlorine gas), sodium hypochlorite solution or dry calcium hypochlorite. When applied to water, each of these forms "free chlorine," which destroys pathogenic (disease-causing) organisms.

Almost all U.S. systems that disinfect their water use some type of chlorine-based process, either alone or in combination with other disinfectants. In addition to controlling disease-causing organisms, chlorination offers a number of benefits including:

- Reduces many disagreeable tastes and odors;
- Eliminates slime bacteria, molds and algae that commonly grow in water supply reservoirs, on the walls of water mains and in storage tanks;
- Removes chemical compounds that have unpleasant tastes and hinder disinfection; and
- Helps remove iron and manganese from raw water.

In addition, only chlorine-based disinfectants can provide a "residual" level to prevent microbial re-growth in treated water. The U.S. Environmental Protection Agency (EPA) requires water systems to maintain disinfection residuals all the way to consumers' taps.

The Risks of Waterborne Disease*

Where adequate water treatment is not readily available, the impact on public health can be devastating. Worldwide, about 1.2 billion people lack access to safe drinking water, and twice that many lack adequate sanitation. As a result, the World Health Organization estimates that nearly two million people, mostly children, die every year from infectious diarrhea attributable to unsafe water.

Even where water treatment is widely practiced, constant vigilance is required to guard against waterborne disease outbreaks. Well-known pathogens such as *E. coli* are easily controlled with chlorination, but can cause deadly outbreaks given conditions of inadequate or no disinfection. A striking example occurred in May 2000 in the Canadian town of Walkerton, Ontario. Seven people died and more than 2,300 became ill after *E. coli* and other bacteria infected the town's water supply. A report published by the Ontario Ministry of the Attorney General concludes that, even after the well was contaminated, the Walkerton disaster could have been prevented if the required chlorine residuals had been maintained.

Some emerging pathogens such as *Cryptosporidium* are resistant to chlorination and can appear even in high quality water supplies. *Cryptosporidium* was the cause of the largest reported drinking water outbreak in U.S. history, affecting over 400,000 people in Milwaukee in April 1993. More than 100 deaths are attributed to this outbreak. New EP regulations require water systems to monitor *Cryptosporidium* and adopt a range of treatment options based on source water *Cryptosporidium* concentrations. Most water systems are expected to meet EPA requirements while continuing to use chlorination.

<u>The Challenge of Disinfection Byproducts</u>*

While protecting against microbial contamination is the top priority, water systems must also control disinfection byproducts (DBPs), chemical compounds formed unintentionally when chlorine and other disinfectants react with natural organic matter in water. In the early 1970s, EPA scientists first determined that drinking water chlorination could form a group of byproducts known as trihalomethanes (THMs), including chloroform. EPA set the first regulatory limits for THMs in 1979. While the available evidence does not prove that DBPs in drinking water cause adverse health effects in humans, high levels of these chemicals are certainly undesirable. Cost-effective methods to reduce DBP formation are available and should be adopted where possible. However, the World Health Organization has strongly cautioned:

> *"In order to ensure the microbial safety of drinking-water, disinfection should never be compromised in trying to meet guidelines for any disinfection by-products".*

Recent EPA regulations have further limited THMs and other DBPs in drinking water. Most water systems are meeting these new standards by controlling the amount of natural organic material prior to disinfection.

<u>Chlorine and Water System Security</u> * (link to "Drinking Water and Security")

The prospect of a terrorist attack has forced water systems, large and small, to re-evaluate and upgrade existing security measures. Each system must assess its potential vulnerability to acts such as chemical or biological contamination of the water supply, disruption of water treatment or distribution, and intentional release of treatment chemicals.

As part of these vulnerability assessments, systems assess the transportation, storage and use of treatment chemicals. While necessary for delivering safe water, these chemicals may pose significant hazards, if released. Water systems using elemental chlorine, in particular, must determine whether existing protection systems are adequate. If not, they must consider additional measures to reduce the likelihood of an attack or to mitigate the potential consequences.

<u>The Future of Chlorine Disinfection</u>*

Despite a range of new challenges, drinking water chlorination will remain a cornerstone of waterborne disease prevention. Chlorine's wide array of benefits cannot be provided by any other single disinfectant. While alternative disinfectants (including chlorine dioxide, ozone, and ultraviolet radiation) are available, all disinfection methods have unique benefits, limitations, and costs. Water system managers must consider these factors, and design a disinfection approach to match each system's characteristics and source water quality.

In addition, world leaders increasingly recognize safe drinking water as a critical building block of sustainable development. Chlorination can provide cost-effective disinfection for remote rural villages and large cities alike, helping to bring safe water to those in need. Where safe, piped water supplies are not available, chlorine can also be used for treating water in individual households, dramatically reducing risks of waterborne disease.

*please add hyperlinks from these titles to the corresponding chapters of *Drinking Water Chlorination: A Review of Disinfection Practices and Issues*.