Chlorine & Drinking Water:

Celebrating a Century

Chlorination remains a cornerstone of waterborne disease prevention

This year, America celebrates the 100th anniversary of one of the most significant public health advances in U.S. history—the chlorination of drinking water. Treatment plants in Jersey City, N.J., and Chicago began to routinely chlorinate municipal drinking water in 1908. Over the next decade, more than 1,000 U.S. cities adopted this life-saving technology.

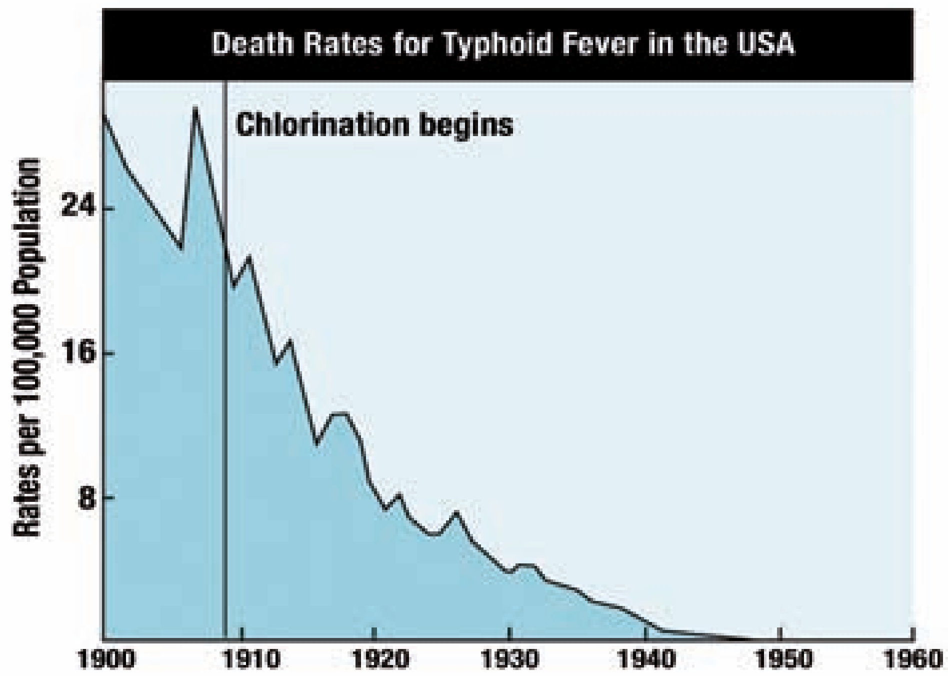
By Jeffrey Sloan

Since then, waterborne illnesses like cholera and typhoid, which once killed thousands of Americans each year, have been virtually eliminated. Today, with a growing variety of water quality challenges, chlorine remains the disinfectant of choice for the majority of water systems.

Effective, Versatile Disinfection

Chlorine is highly effective against a broad range of disease-causing microorganisms. It can be applied as elemental chlorine (chlorine gas) or through the use of chlorinating chemicals such as sodium hypochlorite (liquid bleach) or calcium hypochlorite (tablets or granules). While varying in concentration, each form produces "free chlorine" to attack germs in water.

Chlorine also provides a residual level of disinfectant, required by the U.S. Environmental Protection Agency (EPA) to help protect water



Source: U.S. Centers for Disease Control and Prevention, Summary of Notifiable Diseases, 1997.

all the way to consumers' taps. This residual benefit is particularly important for cities with aging water infrastructure.

A number of alternative disinfection methods are available for drinking water systems, including ozone, chlorine dioxide and ultraviolet radiation. Each disinfection technology has unique strengths and limitations. No single disinfection method is appropriate for all circumstances, and, in fact, a multistep process may be appropriate to meet overall treatment goals.

Regulations & Challenges

One challenge facing water utilities is disinfection byproducts (DBPs), chemical compounds formed unintentionally when disinfectants react with natural organic matter in sourcewater. The EPA enacted the first DBP regulations in 1979, after scientists determined that drinking water chlorination could form chloroform and other DBPs known as trihalomethanes (THMs).

Since then, the agency has further tightened THM standards and enacted rules on other DBPs, most recently in 2006 with the Stage 2 Disinfectants and Disinfection Byproducts Rule. These rules were designed to reduce DBP exposures while maintaining protection against microbial contaminants.

All disinfectants form DBPs. While much research and attention has focused on a few specific compounds, more than 600 DBPs have been identified. EPA research suggests that alternative disinfectants may reduce regulated byproducts such as THMs but increase the concentrations of other DBPs of concern.

The DBP levels can be controlled through cost-effective methods, particularly by reducing the amount of natural organic material in water, through filtration or other means, prior to disinfection. However, as noted by the American Academy of Microbiology, "The health risks posed by microbial pathogens should be placed as the highest priority in water treatment to protect public health."

Other challenges facing water systems involve emerging microorganisms, including *Cryptosporidium*, which is resistant to normal chlorination practices. A *Cryptosporidium* outbreak caused 100 deaths and sickened more than 400,000 people in Milwaukee in 1993, the largest drinking water-related disease outbreak in U.S. history.

The EPA's new Long-Term 2 Enhanced Surface Water Treatment Rule requires systems to monitor *Cryptosporidium* in their source-water and apply additional treatment steps based on potential risks. The EPA has identified a range of options to achieve the requirements, including watershed management and membrane filtration. Systems with high levels of *Cryptosporidium* may also adopt disinfection methods known to be effective against the pathogen (e.g., ozone, UV or chlorine dioxide).

Regardless of the disinfection method used, water systems must continue to rely on chlorine to provide residual disinfection in the distribution system.

Another key issue is security. Protecting water systems against intentional wrongdoing has always been a concern. In recent years, the prospect of a terrorist attack has forced all water systems to re-evaluate and upgrade existing security measures. As part of an overall security strategy, each water system should consider its transportation, storage and use of chlorine gas and other treatment chemicals. Disinfectants are crucial to security, providing the front line of defense against potential biological contamination of water supplies, but could pose significant hazards if released.

Some possible measures to strengthen chemical security include: enhanced physical barriers, policy changes (e.g., tightened procedures for receiving chemical shipments), reducing quantities stored on site or adopting alternative disinfection methods (e.g., replacing chlorine gas with sodium hypochlorite). Water system officials, however, must evaluate the risk tradeoffs associated with each option and prioritize steps based on the characteristics and needs of each system.

A Global Need

More than one billion people lack access to safe drinking water, and twice that many lack adequate sanitation. As a result, the World Health Organization (WHO) estimates that nearly two million people, mostly children, die every year from infectious diarrhea attributable to unsafe water. Much of this disease burden could be prevented with appropriate water treatment and proper sanitation and hygiene practices.

Recognizing the critical link between safe water and sustainable development, the United Nations has set a target to reduce by one-half the number of people without access to safe water by 2015. Meeting this goal will require sustained, coordinated action and billions of dollars worth of investment each year.

A man tests chlorine residuals in Yamaranguila, Honduras.

Where community water systems do not yet exist, disinfected water can also be provided on an individual household level with immediate benefits. A growing number of organizations are working to promote simple techniques for safely treating water at home. The WHO has stated, "Household approaches, including treatment with chlorine disinfectants, have shown to be extremely cost-effective, rapidly deployable and can lead to significant health gains."

What Lies Ahead?

A century after Chicago and Jersey City began routine chlorination of drinking water, disinfection remains the most important step in water treatment. In response to new regulations and emerging science on microbial contaminants, as well as safety and security concerns related to treatment chemicals, water system managers will continue to evaluate chlorine and other disinfection methods. Because chlorine's wide range of benefits cannot be provided by any other single disinfectant, chlorination will remain a cornerstone of waterborne disease prevention. *wqp*

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