

Chlorine

A Cheap and Efficient Killer

By Greg Reyneke

The water that most of us drink is stored, treated and distributed to our homes by public and private water utilities. Algae, bacteria, fungi and viruses can often be found in untreated water. Americans have grown to expect a safe drinking water supply, but achieving that level of safety is a complex task.

One hundred and fifty years ago, much of the US water supply was teeming with various forms of aquatic organisms. Waterborne diseases, such as cholera, typhoid and dysentery were serious health problems. They are still major concerns in underdeveloped nations where over a billion people lack clean drinking water and almost two billion lack adequate sewage systems.

In 1992, the World Bank rated drinking water as first on its list of preventable environmental hazards worldwide. Since 1991, the largest cholera epidemic in recent history infected over 800,000 people from Peru to Mexico.

Waterborne micro organisms

Waterborne micro organisms include coliforms and heterotrophic bacteria, viruses and protozoa. These organisms range in size from extremely small viruses to relatively large cysts. They also vary greatly in the nature of their structure, lifecycle and reproduction characteristics.

Pathogenic micro organisms occur naturally in lakes, streams, reservoirs and most surface water sources. Groundwater supplies are now becoming a subject of increasing concern because enteric viruses and other organisms can leach into the groundwater system from the land application or burial of sewage sludge and other treatment wastes.

Since water utilities first began using filtration and disinfection systems a century ago, the risk of disease from drinking water in industrialized countries has been greatly reduced. Despite the significant progress that has been made, there are still numerous disease cases resulting from contaminated drinking water in the US. Health risks from aquatic pathogens range from mild gastrointestinal distress to systemic disease and, in severe cases, even death.

Drinking water systems

There are nearly 250,000 public water supply systems in the US, serving everything from the smallest towns to major

metropolitan centers. Ninety percent of the population receives its water through these community water systems, with the rest using private wells or other individual sources.

The US EPA ranks drinking water pollution as one of the top four environmental threats to health. From 1971 to 1988, there were nearly 137,000 cases of waterborne disease—or an average

of 7,600 cases per year—reported in this country. It is suspected that there were numerous undocumented cases as well, because many cases of gastrointestinal illness are not recognized as part of a larger pattern of waterborne disease.

It has been estimated that only half of waterborne disease outbreaks in community water systems and about one third of those in non-community systems are ever detected, investigated or reported. Microbes in tap water may be responsible for as much as one in three cases of gastrointestinal illness in the US. Rates of waterborne illness as high as 900,000 cases and 900 deaths per year have been estimated by the Natural

Resources Defense Council (NRDC).

In the 19th century, progressive American communities began to separate drinking water delivered to users from household and industrial wastes discharged into sewage water systems. Many people in developing countries still do not have completely separate drinking water and sewer systems.

Killer chlorine

Water utilities in the US began treating drinking water with chlorine in 1908. Chlorine and its compounds are currently used by over 98 percent of all US water utilities that disinfect drinking water—it is a cheap and efficient killer.

By adding chlorine and its compounds to drinking water, almost all organisms living in the water are killed. Chlorine remains in the water as it is distributed to homes and businesses, thereby retaining much of its ability to continue killing. Although chlorine's disinfectant value has been known for nearly a century, the mechanism by which the compound kills or inactivates micro organisms is still not completely understood.

The municipal water treatment process involves a series of different steps. Some of the major steps include: flocculation and coagulation (joining of small particles of matter in water into larger ones that can more readily be removed); sedimentation (settling of suspended particles in water to the bottom of basins

The concept is to disinfect and protect the water with industrial chemicals like chlorine until it reaches the home. Then the chlorine and disinfection byproducts can be removed before exposure through showering, bathing and drinking.

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from which they can be removed); filtration (filtering or straining water through various types of materials to remove much of the remaining suspended particles) and also chemical disinfection.

Chlorination is usually performed at several stages of the water treatment process. Pre-chlorination may be performed in the initial stages to combat algae and other aquatic life that could interfere with treatment equipment and subsequent stages in the process.

The major chlorination stage, however, occurs as the final treatment step after completion of other major cleaning processes, where concentration and residual content of the chlorine can be closely monitored. In this phase, the chemical is more active and less contact time is required to properly disinfect the water supply.

Chlorine effectiveness

Chlorination can deactivate micro organisms by a variety of mechanisms, such as damage to cell membranes, inhibition of specific enzymes and destruction of nucleic acids and mechanisms. The effectiveness of the chlorination process depends upon a variety of factors, including chlorine concentration and contact time, water temperature, pH value and level of turbidity.

Chlorination remains the most effective and cost-efficient way to disinfect water that is stored, processed and distributed to homes and businesses at a municipal level. It helps protect us all from deadly microbial diseases.

When chlorine is exposed to organic contaminants, certain disinfection byproducts (DBPs) are formed. For example, naturally occurring fulvic and humic acids in water will react with chlorine to form a toxic soup containing numerous compounds such as trihalomethanes, halocatic acids, trichloroacetic acid and others.

Chlorine will also react with biofilms of heterotrophic bacteria so common in piping systems and many water treatment devices. Over 600 DBPs have been identified in drinking water treated by chlorine or chloramine.

Health concerns

Epidemiological studies have related exposure to chlorine DBPs with birth defects, pregnancy complications, respiratory stress, eye irritation, skin damage, headaches and fatigue. It has also been related to certain cancers like bladder, rectal and kidney (recent studies suggest there might even be a causal relationship between chlorine byproducts and breast cancer).

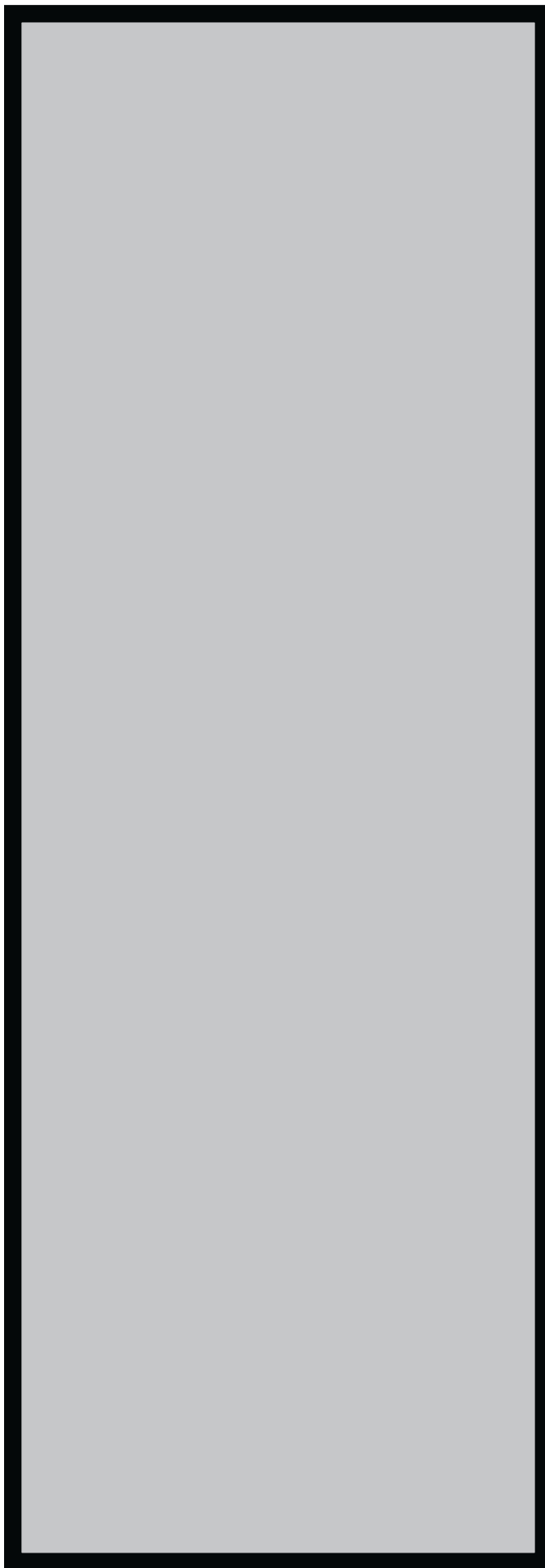
Traditionally, the risk of chlorine and DBPs has been downplayed, since the risk of non-chlorination is significantly greater. In fact, the WHO recently stated, "the risk of death from pathogens is at least 100 to 1,000 times greater than the risk of cancer from disinfection by-products (DBPs) {and} the risk of illness from pathogens is at least 10,000 to one million times greater than the risk of cancer from DBPs."

Essentially, the consumer is being told that they must choose between illness and/or death from disease and micro organisms, or a steady decline in quality of life from the permanent damage caused by chlorine and its byproducts of disinfection. Thankfully, modern water improvement technology allows the consumer a third choice.

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This is analogous to nature's super-food, the lowly banana. I learned the hard way as a youngster growing up in Africa that the banana peel keeps its delicate fruit safe until ready to eat.

Even though the monkeys in our neighborhood ate banana



		Tastes and odors	Chlorine	DBPs	High flow rates	Bacteriostatic	Self cleaning	Self disinfecting
Good	Carbon cartridge	✓	✓	✓				
Better	Upflow carbon filter	✓	✓	✓	✓			
	Bacteriostatic upflow carbon filter	✓	✓	✓	✓	✓		
	Self-backwashing carbon filter	✓	✓	✓	✓		✓	
	Bacteriostatic self-backwashing carbon filter	✓	✓	✓	✓	✓	✓	
Best	Bacteriostatic self-backwashing carbon filter with automatic disinfection apparatus	✓	✓	✓	✓	✓	✓	✓

peels, they were definitely not fit for human consumption! I had to remove the protective skin before trying to eat the fruit.

Multi-level treatment

As a water treatment professional, your primary responsibility is to provide your clients with the very best water at a reasonable price in an environmentally responsible manner. You have many options available to protect your clients and their entire home from chlorine and its dangerous disinfection byproducts.

The simplest option is a replaceable carbon cartridge, but it has a major downside of restricted flow and pressure. Most professionals should consider a whole-house (POE) system that meets consumers' budget and performance requirements.

I always recommend the inclusion of bacteriostatic components in carbon filters and encourage the use of an automatic disinfection injection apparatus. This helps ensure that carbon absorption/adsorption media doesn't become a haven for bacteria.

Regardless of the system that is installed, make sure to properly disinfect it after installation with a non-chlorine disinfectant. Replace carbon and other



media on a regular maintenance schedule as recommended by the media and/or equipment manufacturer.

Always be sure to use dechlorination equipment that is manufactured to comply with NSF standards.

About the author

◆ *Greg Reyneke, CWS-VI, is currently General Manager at Intermountain Soft Water in Lindon, UT and serves on the WC&P Technical Review Committee. He also serves on the advisory board of the Smart Dealer Network, a trade association dedicated to helping independent water treatment dealers succeed in today's changing world and reach their full potential.*



Definitions

Trihalomethanes (THMs)

Chemical compounds where three of the four hydrogen atoms of methane are replaced by halogen atoms. Many trihalomethanes are used in industry and the home as solvents or refrigerants. THMs are generally considered environmental pollutants and many are actually carcinogenic. The US EPA currently limits THMs (chloroform, bromoform, bromodichloromethane and dibromochloromethane) to 80 ppb in treated water.

Haloacetic acids (HAAs)

Carboxylic acids where a halogen atom replaces a hydrogen atom in acetic acid. Haloacetic acids in varying forms are common DBPs of chlorination.

Chloroform

A THM reagent/solvent that is considered an environmental hazard. Chloroform is often inadvertently synthesized during the water treatment process when chlorine and related compounds are added to water. The US Department of Health and Human Resources National Toxicology Program's 11th report on carcinogens implicates chloroform as a human carcinogen, a designation equivalent to International Agency for Research on Cancer Class 2A. It has been most readily associated with hepatocellular cancer. Chloroform once appeared as an ingredient in toothpastes, cough syrups, ointments and other pharmaceuticals, which was banned in the US as a consumer product ingredient in 1976.

Got a problem with your water?

Send your questions to our team of water experts and you'll have a crystal clear solution in no time. Be sure to include your name and location so that we can feature you in our periodic column.

Contact:
Editorial Department
Water Conditioning & Purification Magazine

2800 E. Fort Lowell Road
Tucson, AZ 85716 USA
Tel: (520) 323-6144 • Fax: (520) 323-7412
dmounce@wconline.com
droberts@wconline.com