



# A Brief History of the Role of Ozone in Water Bottling

By L. Joseph Bollyky, Ph.D., P.E.

Ozone treatment is one of the most effective processes for a microbiological barrier that water bottlers can provide for protection of consumers against microorganisms. Many consumers, however, don't know that many bottlers rely on ozone to provide a safe and good tasting product worldwide. Since the 1970s, ozone has played a critical role in helping the bottled water industry deliver a safe and aesthetically pleasing product. In fact, one could say that ozone saved the bottled water industry in the early days when bottled water wasn't always properly disinfected and was frequently criticized in television and newspaper investigative reports.

Today, a few bottlers in the United States may face a new challenge applying ozone without exceeding the newly established disinfection by-product (DBP) maximum contaminant level (MCL) for the bromate ion. Because of the relative and perceived ease of ozone treatment, many bottlers still don't use proven ozone process controls and monitoring technology. Thus, they're yet to assure precise ozone treatment, which is necessary when certain contaminants such as bromide—from which bromate is formed—are present in the source water. The careful use of controls can result in better quality, bottled water.

## Why bottlers rely on ozone?

Ozone treatment played a pivotal role early in the bottled water industry and contributed to the healthy growth the industry has enjoyed for many years. In the early years (1970s) of the water bottling industry, not all the water bottlers used ozone treatment for disinfection. In addition, the water bottling process wasn't developed fully nor was the bottled water always sealed properly. During the handling and squeezing of the bottle, air and airborne organisms could enter the bottle. Thus, after days

or weeks of storage—often on supermarket shelves—the potential existed for the explosive growth of microorganisms in bottled water, which could lead to taste, odor and health problems. Several well-publicized bottled water recalls took place during that time.

Shortly thereafter, under pressure from many state health organizations, disinfection processes for water bottling—with ozone as a key component—were developed. The required ozone dosages, contact times, and closure requirements for the various types of bottles and waters were developed. Ozone proved to be the magical oxidant that could disinfect the water, bottling equipment, bottle and the sealed cap, and then decompose to harmless oxygen and thereby disappear without leaving a taste or odor.

Ozone disinfection enabled the water bottler to produce good quality, storage-stable bottled water that was free of by-products, taste and odor associated with the use of chlorine for disinfection/oxidation. These characteristics and the claims of good-tasting, odor-free, pollution-free, storage-stable, healthy water led to the rapid growth of the bottled water industry in the 1980s and 1990s with overall public consumption growth consistently approaching or exceeding double digit rates (see *Figures 1&2*).

## Ozone

Ozone (O<sub>3</sub>) is a gaseous material made from oxygen in an electric discharge field (corona discharge) type ozone generator. Today, the output of the ozone generator typically contains 3-10

Figure 1. U.S. bottled water market in gallons & dollars, 1990-2000

Year	Gallons (millions)	Change	Dollars (US\$ millions)	Change
1990	2,237.6	9.5%	\$2,481.9	13.2%
1995	3,167.5	9.2%	\$3,455.4	11.3%
1996	3,449.3	8.9%	\$3,760.7	8.8%
1997	3,775.8	9.5%	\$4,141.5	10.1%
1998	4,146.0	9.8%	\$4,576.0	10.5%
1999	4,646.1	12.1%	\$5,211.4	13.9%
2000	5,033.2	8.3%	\$5,695.7	9.3%

SOURCE: Beverage Marketing Corp., New York, via IBWA website: [www.bottledwater.org](http://www.bottledwater.org)

Figure 2. U.S. bottled water market volume & growth by segment, 1990-2000

Year	Non-Sparkling		Sparkling		Imports		Total	
	Volume	Change	Volume	Change	Volume	Change	Volume	Change
1990	1,987.7	8.0%	176.0	12.7%	73.9	32.9%	2,237.6	10.3%
1996	3,178.5	9.9%	159.0	-3.7%	111.8	15.1%	3,449.3	8.9%
1997	3,472.9	9.3%	153.8	3.4%	149.1	33.4%	3,775.8	9.5%
1998	3,839.1	10.5%	146.1	5.3%	160.8	7.8%	4,146.0	9.8%
1999	4,349.1	13.3%	146.0	0.1%	151.1	-6.0%	4,646.1	12.1%
2000	4,751.1	9.2%	144.2	-1.2%	137.8	-8.8%	5,033.2	8.3%
<b>90-00</b>		<b>8.2%</b>		<b>-1.8%</b>		<b>5.8%</b>		<b>7.6%</b>

SOURCE: Beverage Marketing Corp., New York, via IBWA website: [www.bottledwater.org](http://www.bottledwater.org)

percent weight (% w.t.) of ozone in the un-reacted oxygen feed gas stream. Early ozone generators operated at 1-2 percent w.t. ozone. This ozone gas stream is brought into contact with the water to be treated in a device called an ozone contactor. In the ozone contactor, the ozone is dissolved in the water and the undissolved ozone in the off-gas is discharged through an ozone decomposer and released at rooftop levels.

Ozone is a powerful oxidant and an exceptional chemical disinfectant. The ozone treatment process is an integral part of the drinking water treatment plant operation in more than 3,000 municipal water installations worldwide. These plants supply water to the residents of many major international cities like London, Paris, Budapest, Kiev, Moscow and Singapore. In the United States alone there are nearly 400 other ozone drinking water installations including those in Los Angeles, Dallas, Milwaukee, Orlando, Atlanta and soon Boston and New York City.

### ***Bottled water treatment***

The ozone/water contacting system serves two primary functions. First, it's used for the dissolution or mass transfer of the ozone gas from the output gas stream mixture of the ozone generator into the water to be treated. The balance of the ozone remaining in the off-gas is destroyed by an ozone decomposer unit, so that any off-gas discharged into the atmosphere contains an ozone concentration less than 0.1 parts per million (ppm)—or milligrams per liter (mg/L)—of ozone.

### ***Reactions of ozone***

Second, the ozone contactor is a reactor. It provides the reaction time—detention or contact time—to allow the desired disinfection and/or oxidation processes to occur in the water. Once the ozone is dissolved in the water, it undergoes three simultaneous reactions:

**1. Disinfection:** The disinfection treats the water against bacteria, viruses and parasites such as *Giardia* and *Cryptosporidium*. While much more detail can be given (see *FYI*), suffice it to say that ozone is highly effective against all the above microorganisms and more.

**2. Chemical oxidation:** Ozone is a powerful oxidizing agent and very effective against essentially all taste and odor-causing organic materials and oxidizable inorganics like iron, manganese and the sulfide ion. Again, additional detail on the specifics of this reaction has

## FYI—More on Ozone

For additional information on ozone, how it works, particular applications and other issues, visit the following articles in your *WC&P* archives:

- Niche Markets: Using Your Ozone Expertise to Open Doors into Small Municipal Systems  
*Ken Larson, February 2000*
- WQA Ozone Task Force: An Update  
*Paul K. Overbeck, March 2000*
- Ozone and Food Processing—From Fresh Produce to Seafood, a Niche Market Grows  
*Christopher Lee, CWS-V, and Ronald Rogers, June 2000*
- Ozone Generators—Is 'Apples to Apples' Performance Evaluation Possible?  
*Tim Teffeteller, June 2000*
- Combining Ozone with UV—Advanced Oxidation Process for Swimming Pool Applications  
*Omar Legrini, Ph.D., & Gaspar Lesznik, June 2000*
- Bottled Water: DBPs & the Water Industry—The Bromide/Bromate Issue, a Concern for Bottlers and Other Ozone Users  
*Henry R. Hidell III, October 2000*
- Ozone: Airing It Out at the Water Store—A Market Niche  
*Ted K. Rich, October 2000*
- Ozone: Water Stores Take Advantage of an Alternative Disinfectant  
*Roger Nathanson, March 2001*
- Ozone & Government Regulations: An Update  
*Paul K. Overbeck, March 2001*
- Ozone: Treatment Applications for POU/PE and Small Water Systems  
*Thomas P. Palkon, CWS-VI, March 2001*
- Expect ANSI/NSF Ozone Generator Standard in 2002  
*Carlos David Mogollón, March 2001*
- In-Transit Ozone Water Treatment Systems: Necessity is the Mother of Invention  
*G. Scott Fahey, P.E., March 2001*
- Catalytic Destruction of Ozone: A Cost-Effective Approach to Controlling Off-Gas Emissions  
*Joseph Sigmund, March 2001*
- Ozone Generation Technology: Past, Present & Future  
*Dale Mork, August 2001*
- Viewpoint: Perrier Restricts Ozone Use Awaiting Better Control Options  
*Carlos David Mogollón, August 2001*

been expanded upon in other articles (see *FYI*).

**3. Decomposition:** Ozone is an unstable material under room, or near room, temperature conditions and decomposes to oxygen fairly quickly. The decomposition rate is influenced primarily by water temperature and pH. The half-life of ozone at 20°C and pH 7.0 is typically 24 minutes in potable tap water.

### **Ozone's role**

The objectives of ozone treatment in water bottling include:

- Disinfection of water against all microorganisms that might be present in the water.
- Disinfection of bottles, especially reusable bottles in the wash prior to bottling.
- Disinfection of the wetted parts of the water-bottling equipment and machinery.
- Disinfection of the surface of the bottle and the sealed cap of the bottled water.
- Disinfection against the airborne microorganisms that may be

present in the bottled water in the air above the water.

### **Conclusion**

Ozone treatment is a unique process. It can accomplish all the aforementioned treatment objectives without leaving a taste or chemical residual behind when thoughtfully applied and controlled. Ozone is an exceptionally powerful disinfectant and oxidant. It does its job and disappears. And with appropriate pretreatment and careful monitoring and controls, it can leave water relatively free of disinfection by-products as well. Should you wish for an ideal disinfectant for bottled water, you couldn't ask for a better one.

### **About the author**

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