Ozone Disinfection of Water: Applications and Effects on Microorganisms

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Abstract

Ozone is an effective, efficient way to disinfect water without harmful residuals. It was widely used in Europe in the 1930s, but is not commonly used today in the United States. Ozone effectively inactivates bacteria, viruses, spores, and amoebae. The exact mechanism of ozone disinfection is not known, and is the subject of much study. In *Escherichia coli*, a likely mechanism is attack of the double bonds of fatty acids in the cell wall and membrane of the bacterium (McNair and Lesher, 1963). Disinfection efficiency increases as temperature increases and is not affected by pH or turbidity. The presence of ozone consuming compounds in the water also affects efficiency. Ozonation is more effective than chlorination at improving water quality. Ozone is effective at inactivating the Norwalk virus when applied for 10 seconds at a 37 mg/L dose (Shin and Sobsey, 2003). Ozone water can also be used to safely treat chlamydial infections (Yamazaki et al., 2004). Ozone can be used in a recirculating seawater system, but with varying rates of successful inactivation (Hsieh et al., 2004). Disadvantages of ozone disinfection include toxicity of ozone gas, complex equipment, and a high cost of treatment systems.

Keywords

Ozone, disinfection, inactivation, microorganisms, inactivation mechanism

Introduction

The odor of ozone was first noticed by Van Murum in 1785, near an electrical machine (Evans, 1972). The name ozone, comes from the Greek *ozein,* meaning “to smell”. Ozone gas owes its name to its characteristic odor. Eventually this odor was traced to triatomic oxygen, O_3. Ozone’s first important commercial use was in water disinfection. Several experimental plants were used as early as 1892, but the first important plant went into operation in Nice, France in 1906. By 1936, there were 100 municipal installations in France, and 30 to 40 more in other countries. Ozone’s peak development for water disinfection occurred right after its commercial introduction.

In July 1940, Whiting, Indiana began using ozone generating equipment to remove the tastes and odors produced by chlorinating water from Lake Michigan (Evans, 1972). This was the first ozone disinfection system used in the United States. Ozone is colorless at room temperature, and condenses to a dark blue liquid when cooled. It has a characteristic pungent odor. It is generally encountered in dilute form in a mixture of oxygen with air. Ozone is produced when oxygen molecules (O_2) are broken apart by energy into single oxygen atoms. This single oxygen atom then collides with an oxygen molecule to form ozone, or O_3, which can be used to disinfect wastewater. Most wastewater treatment plants generate ozone through the use of a high voltage alternating current. The current is conducted across a dielectric discharge gap containing oxygen gas (Wastewater, 1999). Ozone must be generated onsite at the disinfection area because it is very unstable and will decompose quickly.

Ozone disinfection is generally used at medium to large sized plants after at least secondary treatment (Evans, 1972). It can also be used for primary treatment. In addition to disinfection, another common use for ozone in wastewater treatment is odor control. Ozone disinfection is the least used method in the U.S. although this technology has been widely accepted in Europe for decades. Ozone treatment has the ability to achieve higher levels of disinfection than either chlorine or UV, however, the capital costs as well as maintenance expenditures are not