# Evaluating the Effectiveness and Feasibility of Commercial Ozone Technologies Used for Sanitation of Work Area and Laundry Services

## Publication

1. Fujioka, R.S.; D.M. Sato; B.S. Yoneyama, 2006, Evaluating the Effectiveness and Feasibility of Commercial Ozone Technologies Used for Sanitation of Work Area and Laundry Services, WRRC-2006-04, Water Resources Research Center, University of Hawaii at Manoa, Honolulu, Hawaii, 82 pages (final project report to U.S. Army Pacific (USARPAC), Fort Shafter, Hawaii 96858 and to U.S. Geological Survey, Office of Acquisition and Grants, Reston, Virginia, 20192).

**Problem and Research Objectives**

The U.S. Army Pacific (USARPAC) has a mandate to improve its operational needs in terms of efficiency, cost, and safety for personnel and the environment. Many of the existing technologies it uses require harsh chemicals (chlorine, solvents, acids) that increase loads of pollution to the environment. For systems such as laundry services, the energy used to heat water is costly, and the discharge of detergents and other harsh chemical additives are sources of environmental pollution. Currently, several commercial companies advertise that application of ozone technology will address many of the negative effects associated with such systems. One commercial company in Hawaii, Ozone Industries, Inc., provides ozone technology to enhance laundry services at Fort Shafter Laundry Services and to enhance sanitation of workplace areas at Times Supermarkets. This technology is used because ozone, considered the fifth most-reactive chemical, is the only highly reactive chemical that can be practically applied.

There are two desirable chemical reactions with ozone. At relatively high concentrations, it oxidizes or breaks down the structural bonds of a complex organic molecule (e.g., proteins, fats, sugars, carbohydrates) to basic, nontoxic molecules such as $CO_2$ and $H_2O$. When this occurs, any undesirable property associated with a specific structure of an organic molecule is destroyed without forming intermediate products. At lower concentrations, ozone is an effective disinfectant of microorganisms, including the more resistant forms. However, there are two disadvantages with ozone use. First, only a limited concentration can be dissolved in water. Second, because ozone reacts with almost everything, its concentration is quickly reduced during application.

The goal of this study was to obtain independent laboratory-based performance data to evaluate the effectiveness, feasibility, and safety of commercial ozone technologies (Ozone Industries, Inc.) as applied in the state of Hawaii for sanitation of workplaces (e.g., disinfecting cutting boards at Times Supermarkets) and enhancement of laundry services (disinfecting linen, towels, sheets at Fort Shafter).

**Methodology**

The experimental design of this study was to measure the visual and bacterial quality (concentration of total bacteria) of food cutting boards used at supermarkets and fabrics cleaned at a military laundry facility before and after ozone treatment and then to compare the results with cleaning procedures that did not use ozone. Treatment was accomplished by generating ozone gas in water and then using the ozonated water to disinfect cutting boards. The ozone water was also used in some of the laundry cycles to clean fabrics. Concentrations of ozone in the water before and after it was used were measured using the Hach 8311 indigo method. Concentrations of total bacteria on cutting boards and on laundry products were measured using the semiquantitative Rodac plate method or the quantitative alginate swab method which allowed total bacterial colonies to be counted on Tryptic Soy Agar plates. Visual, textural, and odor assessments of fabrics before and after laundry cycles were also made. In some experiments, fabrics were purposely stained with food, blood, and ink to determine effectiveness of laundry cycles with and without ozone treatments.

**Principal Findings and Significance**

During phase 1 of this study, the effectiveness of ozone technology to clean cutting boards at supermarkets was assessed. It was determined that the amount of residual bacteria recovered from cutting boards with and without ozone treatment was similar. Although ozonated water was shown to be capable of inactivating 90% of bacteria in water, most of the bacteria on cutting board surfaces were already removed by standard cleaning procedures, which includes hot detergent scrubbing, followed by rinsing with tap water and then treatment with surfactants, a kind of disinfectant. The residual concentration of total bacteria recovered from cutting boards cleaned only with standard cleaning procedures and that recovered after additional treatment with ozone were similar. The residual level of bacteria was determined to be due to the formation of a biofilm of bacteria which occurs on all moist surfaces. The level of total bacteria on cutting board surfaces are most likely not related to health effects, as similar levels of total bacteria can be recovered from vegetables that are consumed raw. In summary, standard cleaning procedures (hot detergent scrubbing, rinsing, disinfecting with surfactant) effectively removed the bacteria left on cutting boards by the foods used during that day, so

final treatment with ozone was not required because bacteria in biofilm remained on the cleaned cutting boards even after ozone treatment as well as after additional treatment with chlorine. These results support those of previous reports that bacteria in biofilm are known to be resistant to disinfectants, but they generally do not cause a health effect for humans. Since no health effects were observed on people at the supermarket utilizing ozone technology, the use of this technology at supermarkets appears to be safe.

During phase 2 of this study, the effectiveness of ozone technology in cleaning fabrics at a military laundry service was assessed. The primary approach was to assess the impact of ozone technology in reducing the concentration of total bacteria and in destaining fabrics by using ozone in the wash cycles. However, the cleaning effectivenss of ozone versus detergent could not be easily distinguished because ozonated water and detergent were used in all cleaning cycles at Fort Shafter Laundry Services. Under experimental conditions, samples of tablecloths and napkins purposely smeared with lipstick, oil-based dressing, and fish blood were laundered using selected cleaning cycles to include washing with only ozonated water. It was revealed that cleaning with cold ozonated water alone was not as effective as cleaning with hot detergent in terms of removing stains and reducing bacterial counts from the fabrics. All of the cycles used were effective in cleaning the fabrics because the laundry facility had already selected appropriate wash cycles to specifically clean different types of fabrics. In summary, the cumulative data showed that ozone technology as applied to Fort Shafter Laundry Services does not appear to measurably enhance laundering performance. A basic problem was the relatively low concentration of ozone in the water and the routine use of this water in all cleaning cycles. Thus, at this facility, ozone was not used in a strategic manner compared to other companies which report using ozone separately as one of the steps in the laundering cycle to enhance the whole cleaning procedure so that detergent use is reduced and lower temperature water is used. Since no health effects were observed on people at this laundry facility, the use of ozone technology for laundry services appears to be safe.