In-line Ozone and Hydrogen Peroxide Treatment for Removal of Organic Chemicals [Project #637]

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Prepared by John E. Dyksen and Russell Ford, Village of Ridgewood, N.J.; Kalyan Raman and James K. Schaefer, Malcolm Pirnie, Inc.; Leo Fung and Barry Schwartz, Hackensack Water Company; and Michael Barnes, Spring Valley Water Company

BACKGROUND

Ozone and hydrogen peroxide have been demonstrated to achieve high removal of the types of organic chemicals found in groundwater supplies. Most studies involving these oxidants have used conventional ozone and hydrogen peroxide dissolution and contacting systems. The objective of this study was to demonstrate the effectiveness of this process using an in-line application of ozone and hydrogen peroxide to remove organic chemicals at much higher pressures than those in conventional systems.

APPROACH

In this study, a pilot plant was designed, constructed, and tested to evaluate organic chemical removals under various ozone and hydrogen peroxide dosages, contact times, and pressures. Ozone mass transfer efficiency and removal of entrained and dissolved gases from the finished water were evaluated under these varying conditions. The water used for testing was obtained from active wells of the Ridgewood (N.J.) Water Department and the Spring Valley (N.Y.) Water Company. Both wells contained trichloroethylene (TCE) and tetrachloroethylene (PCE), and the Ridgewood well also contained methyl tertiary butyl ether (MTBE), a gasoline-related compound that is very difficult to strip from water and very poorly adsorbed using granular activated carbon (GAC).

RESULTS

The tests conducted to evaluate ozone mass transfer efficiency indicated an efficiency of about 90 percent or greater after a contact time of 2 minutes for all ozone dosages (0.5 to 10.8 mg/L) and in-line pressures (25 to 80 psig) tested. Overall, the use of oxygen or air to generate the ozone did not significantly change the ozone mass transfer efficiency. However, the use of oxygen resulted in higher dissolved oxygen levels in the finished water than did the use of air.

Preliminary testing produced finished water with a milky appearance at in-line pressures of 40 psig and greater because of entrained gas and the degasification of dissolved gas. After modification of the air relief device, the pilot plant produced a clear product up to a pressure of 50 psig.

The tests conducted to evaluate process issues indicated poor removals of TCE, PCE, and MTBE using only ozone as an oxidant. The addition of hydrogen peroxide in conjunction with ozone significantly improved the removals of each of these compounds. Removals of greater than 90 percent of TCE and PCE were achieved using ozone dosages of about 6.0 mg/L, contact times of 3 to 6 minutes, and a hydrogen peroxide-to-ozone ratio of 0.5. Nondetectable levels of MTBE were recorded using an ozone dosage of 8 mg/L, similar contact times, and a similar ozone-to-hydrogen peroxide ratio. Longer contact time did not significantly affect the removal of TCE, although it did improve the removal of PCE.

Capital and operating costs of the ozone and hydrogen peroxide process were estimated based on preliminary design of system sizes ranging from 70 gpm to 1,400 gpm. For purposes of comparison, preliminary designs and costs were also prepared for packed tower air stripping (with and without vapor phase treatment) and for GAC adsorption. The preliminary cost comparison indicated that the in-line ozone and hydrogen peroxide process was more cost effective for TCE and PCE removal than GAC adsorption or packed tower air stripping with vapor phase treatment, particularly at flow rates greater than about 400 gpm for the water tested. At lower flow rates, the cost advantage of the in-line process did not appear to be as great, although overall costs were still lower than for the other two processes. Packed tower air stripping alone was the most cost-effective process for all flow rates.

For all flow rates evaluated, the cost estimates prepared for MTBE removal indicated a definite advantage for the in-line process over either packed tower air stripping with vapor phase treatment or GAC adsorption. For MTBE removal, as with TCE and PCE removal, packed tower air stripping alone was the most cost-effective process.

FURTHER RESEARCH RECOMMENDATIONS

1. The pilot plant was capable of producing an aesthetically pleasing finished water at operating pressures of up to 50 psig. However, additional work is needed to demonstrate that air relief devices or arrangements can be successfully designed and operated to produce a clear product water at pressures approaching 80 psig, which are often encountered in distribution systems. Solving the milky water problem at the higher pressures is key to widespread application of this process for treating contaminated groundwater supplies.

2. A wide range of water quality conditions should be tested to develop kinetic relationships for TCE and PCE and to assess the feasibility of the in-line application of ozone and hydrogen peroxide to remove other organic chemicals of concern in groundwater supplies. The effects of other water quality parameters, such as alkalinity and total organic carbon, should also be evaluated.