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SITE
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TECHNOLOGY EVALUATION

Demonstration Bulletin

perox-pure™ Chemical Oxidation Treatment

Peroxidation Systems, Inc.

Technology Description: The perox-pure™ chemical oxidation treatment technology was developed by Peroxidation Systems, Inc. (PSI), to destroy dissolved organic contaminants in water. The technology uses ultraviolet (UV) radiation and hydrogen peroxide to oxidize organic compounds present in water at parts per million (ppm) levels. This treatment technology produces no air emissions and generates no residue, sludge, or spent media that require further processing, handling, or disposal. Ideally, end products are water, carbon dioxide, halides (for example, chloride), and in some cases, organic acids. The technology uses medium pressure mercury vapor lamps to generate UV radiation. The principal oxidants in the system, hydroxyl radicals, are produced by direct photolysis of hydrogen peroxide at UV wavelengths.

The perox-pure™ chemical oxidation treatment system (Model SSB-30) used for the SITE technology demonstration was assembled from the following portable, skid-mounted components: a chemical oxidation unit, a hydrogen peroxide feed tank, an acid feed tank, a base feed tank, a UV lamp drive, and a control panel. The oxidation unit has six reactors in series with one 5-kilowatt UV lamp in each reactor and has a total volume of 15 gal. The UV lamp is mounted inside a UV-transmissive quartz tube in the center of each reactor so that water flows through the space between the reactor walls and the quartz tube.

A schematic flow diagram of the perox-pure™ chemical oxidation unit is shown in Figure 1. Contaminated water enters the oxidation unit through a section of pipe containing a temperature gauge, a flow meter, an influent sample port, and hydrogen peroxide and acid injection points. Contaminated water is dosed with hydrogen peroxide before the water enters the first reactor; however, a splitter can be used to add hydrogen peroxide before any of the six reactors within the oxidation unit. In some applications, acid is added to lower the influent pH and shift the carbonate-bicarbonate equilibrium to carbonic acid. This equilibrium is important because carbonate and bicarbonate ions will scavenge hydroxyl radicals. After chemical injections, the contaminated water flows through a static mixer and enters the oxidation unit. Water then flows through the six UV reactors, which are separated by baffles to direct water flow. Treated water exits the oxidation unit through a pipe equipped with a temperature gauge, an effluent sample port, and a base injection point. Base may be added to the treated water to adjust the pH to meet discharge requirements.

Circular wipers attached to the quartz tubes housing the UV lamps are used periodically to remove any solids that have accumulated on the tubes. Solids may accumulate as a result of metals oxidized by the treatment system (such as iron and manganese), water hardness, or suspended solids that may precipi-

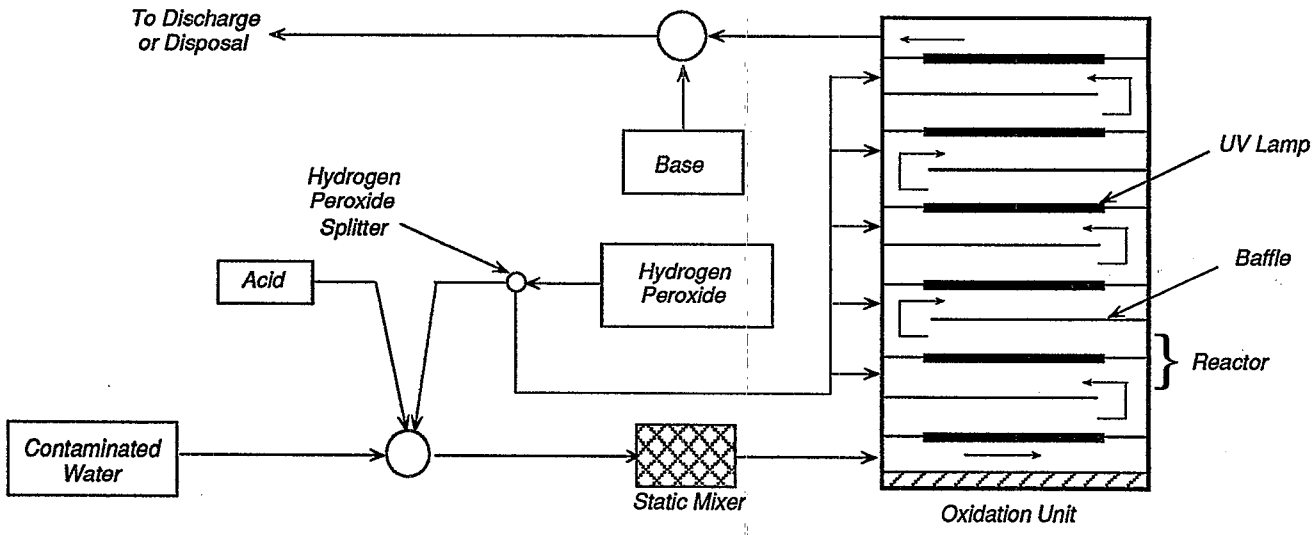

Figure 1. *perox-pure™ chemical oxidation treatment system flow diagram.*

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tate out of the water. Accumulated solids could eventually coat the tubes, thus reducing treatment efficiency.

Waste Applicability: The perox-pure™ technology has been used to treat landfill leachate, groundwater, and industrial wastewater all containing a variety of organic contaminants, including chlorinated solvents, pesticides, polynuclear aromatic hydrocarbons, and petroleum hydrocarbons. In some applications, where the contaminant concentration was too high [about 500 milligrams per liter (mg/L)] for the perox-pure™ system to handle alone, the system was combined with other treatment technologies.

Demonstration Approach: The perox-pure™ chemical oxidation technology was demonstrated at Lawrence Livermore National Laboratory Site 300 in Tracy, California, over a 3-wk period in September 1992. During the demonstration, about 40,000 gal of groundwater contaminated with volatile organic compounds (VOC) was treated. The principal groundwater contaminants were trichloroethene (TCE) and tetrachloroethene (PCE), which were present at concentrations of about 1,000 and 100 micrograms per liter (µg/L), respectively. Groundwater was pumped from two wells into a 7,500-gal bladder tank to minimize any variability in influent characteristics. In addition, cartridge filters were used to remove suspended solids greater than 3 microns from the groundwater before it entered the bladder tank. Treated groundwater was stored in two 20,000-gal steel tanks before being discharged.

The technology demonstration was conducted in three phases. Phase 1 consisted of eight runs, Phase 2 consisted of four runs, and Phase 3 consisted of two runs. These phases are described below.

The principal operating parameters for the perox-pure™ system, hydrogen peroxide dose, influent pH, and flow rate (hydraulic retention time), were varied during Phase 1 to observe treatment system performance under different conditions. Preferred operating conditions, those under which the concentrations of effluent VOCs were reduced below target levels at the least cost, were then determined for the system.

Phase 2 involved spiked groundwater and reproducibility tests. Groundwater was spiked with about 300 µg/L each of 1,1-dichloroethane (DCA); 1,1,1-trichloroethane (TCA); and chloroform. These compounds were chosen because they are difficult to oxidize and because they were not present in the groundwater at high concentrations. This phase was also designed to evaluate the reproducibility of treatment system performance at the preferred operating conditions determined in Phase 1.

During Phase 3, the effectiveness of quartz tube wipers was evaluated by performing two runs using spiked groundwater.

During the demonstration, samples were collected at the following locations: treatment system influent, effluent from Reactor 1, effluent from Reactor 3, and treatment system effluent. These samples were analyzed for VOCs, semivolatile organic compounds, total organic carbon, total carbon, purgeable organic carbon, metals, pH, alkalinity, and hardness. In addition, samples of influent to Reactor 1 and treatment system effluent were collected and analyzed for acute toxicity to fresh water organisms. The hydrogen peroxide, acid, and base solutions and spiked groundwater were also sampled and analyzed to verify concentrations.

Key findings of the SITE demonstration, including sample analytical results, will be discussed in detail in the Applications Analysis Report and the Technology Evaluation Report. Results will also be summarized in a project summary report and a videotape. During the SITE demonstration of the perox-pure™ system, the following preliminary findings were noted:

- Preferred operating conditions from Phase 1 (determined by quick turn-around analyses for selected compounds) were as follows: the influent hydrogen peroxide was 40 mg/L; the hydrogen peroxide in influent to Reactors 2 through 6 was 25 mg/L; the influent pH was 5.0; and the flow rate was 10 gal/min.
- During the three reproducibility runs, average removal efficiencies for chloroform, DCA, PCE, TCA, and TCE after Reactor 1 were 46.1%, 70.3%, 95.9%, 21.0%, and 98.4%, respectively. After Reactor 6, removal efficiencies for chloroform, DCA, and TCA increased to 85.6%, 96.3%, and 75.6%, respectively.
- System setup and shakedown took about 5 days. The system required little or no attention after operating conditions were established. There were no major operational problems that affected system performance.

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