Ground Water, Surface Water, and Leachate

Advanced Oxidation Processes (AOP)

Introduction:

Advanced Oxidation Processes namely ultraviolet (UV) radiation, ozone and hydrogen peroxide (H_2O_2) are utilised to remove organic contaminants in water.

Description:

UV oxidation is a destructive method that oxidises organic contaminants in water by the addition of strong oxidisers and irradiation with UV light. Oxidation of the target contaminants is initiated by direct reaction with the oxidisers, UV photolysis, and the synergistic action of UV light with ozone (O_3) or hydrogen peroxide (H_2O_2). If full mineralisation is achieved, the final products of oxidation are carbon dioxide, water, and salts. The key advantage of UV oxidation is that it is a destructive method, as opposed to air stripping or carbon adsorption, where contaminants are extracted and concentrated in a separate phase. UV oxidation methods can be configured in batch or continuous flow modes, depending on the throughput being consideration.

UV oxidation is generally done with low-pressure lamps operating at 65 watts of electricity for ozone systems, with lamps operating at 15kW to 60kW for hydrogen peroxide systems.

UV photolysis enables the chemical bonds of the contaminants to be broken under the influence of UV light. Products of photo-degradation vary according to the matrix in which the process occurs. However, the complete conversion of an organic contaminant to CO_2 or H_2O is unlikely.

The time duration of operation and maintenance of UV oxidation is dependant upon influent water turbidity, contaminant concentrations, existence of free radical scavengers and the maintenance intervals that are required on UV reactors and quartz sleeves.

Applicability:

Most organic contaminants that are reactive with a hydroxyl radical have the potential to be treated with this process. A wide variety of organic and explosive contaminants are susceptible to destruction by UV/oxidation, including petroleum hydrocarbons, chlorinated hydrocarbons; and compounds such as TNT, RDX, and HMX. In most cases, chlorinated hydrocarbons that are resistant to biodegradation may be treated by UV/oxidation. Typically, easily oxidised organic compounds, such as those with double bonds like TCE, PCE, and vinyl chloride, as well as simple aromatic compounds such as toluene, benzene, xylene, and phenol, are rapidly destroyed in UV/oxidation processes.

Limitations:

- The water stream being treated must provide good transmission of UV light, as high turbidity could cause interference. This factor can be more critical for UV/H_2O_2 than UV/O_3.
- Free radical scavengers can inhibit destruction efficiency. Excessive doses of chemical oxidisers may act as a scavenger.
- The water stream to be treated should be relatively free of heavy metal ions (less than 10 mg/L) and insoluble oil to minimise the potential for fouling of the quartz sleeves.
- When UV/O_3 is used on volatile organics, the contaminants may be volatilised rather than destroyed. They would then require removing from the off-gas by activated carbon adsorption or catalytic oxidation.
- Costs may be higher than competing technologies due to energy requirements.
- Pre-treatment of the water stream may be required to minimize ongoing cleaning and maintenance of UV reactor and quartz sleeves.

- Handling and storage of oxidisers require special safety precautions.

Data Needs:

The design and operation parameters include contact or retention time, influent water turbidity, metals and contaminant concentrations, existence of free radical scavengers, oxidiser influent dosages, pH, temperature, UV lamp intensity, and performance levels of catalysts.

Performance Data:

UV/oxidation is an innovative ground water treatment technology that has been used in full-scale ground water treatment application for more than 10 years. A majority of these applications are for ground water contaminated with petroleum products or a variety of industrial solvent-related organics such as TCE, DCE, TCA, and vinyl chloride.
Numerous sizes of UV/oxidation systems are commercially available. Single-lamp bench top reactors are able to be operated in batch or continuous modes are available for the performance of treatability studies. Pilot and full-scale systems are available to handle higher throughput such as 3,800 to 3,800,000 litres or 1,000 to 1,000,000 gallons per day.

Cost:

Costs generally are around £ 4.00 per 1,000 litres. Factors that influence the cost to implementing UV/oxidation include:

- Types and concentration of contaminants (affect oxidiser selection, oxidiser dosage, UV light intensity, and treatment time).
- Degree of contaminant destruction required.
- Desired water flow rates.
- Need for pre-treatment and/or post-treatment.