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Laser Induced Photochemical Oxidative Destruction

Energy and Environmental Engineering, Incorporated

Technology Description: The process developed by Energy and Environmental Engineering, Incorporated, is designed to photochemically oxidize organic compounds in wastewater by applying ultraviolet radiation using an Excimer laser. The photochemical reactor can destroy low to moderate concentrations of organics in water. The energy is sufficient to fragment the bonds of organic compounds, and the radiation is not absorbed to any significant extent by the water molecules in the solution. The process is envisioned as a final treatment step to reduce organic contamination in ground water and industrial wastewaters to acceptable limits.

The overall reaction chemistry uses hydrogen peroxide as the oxidant in the reaction:

$$C_aH_bX + (2a+0.5\,(b-1))H_2O_2 \xrightarrow{hv} aCO_2 + (2a+(b-1))H_2O + HX$$

where C_aH_bX is a halogenated toxic component in the aqueous phase. The reaction products are carbon dioxide, water, and the corresponding halogen acid, HX.

The existing process equipment has a capacity of 1 GPM when treating a solution containing 32 ppm of total organic carbon. It consists of a photochemical reactor, where oxidation is initiated, and an effluent storage tank to contain reaction products (Figure 1).

The skid-mounted system can be used in the field and stationed at a site. The exact makeup of the process will depend on the chemical composition of the groundwater or wastewater being treated.

Typically, contaminated groundwater is pumped from a feed well through a filter unit to remove suspended particles. The filtrate is then fed to the photochemical reactor and irradiated. The chemical oxidant (H_2O_2) is introduced to the solution to provide hydroxyl radicals required for oxidation.

The reactor effluent is directed to a vented storage tank, where the CO_2 oxidation product is vented. An appropriate base (such

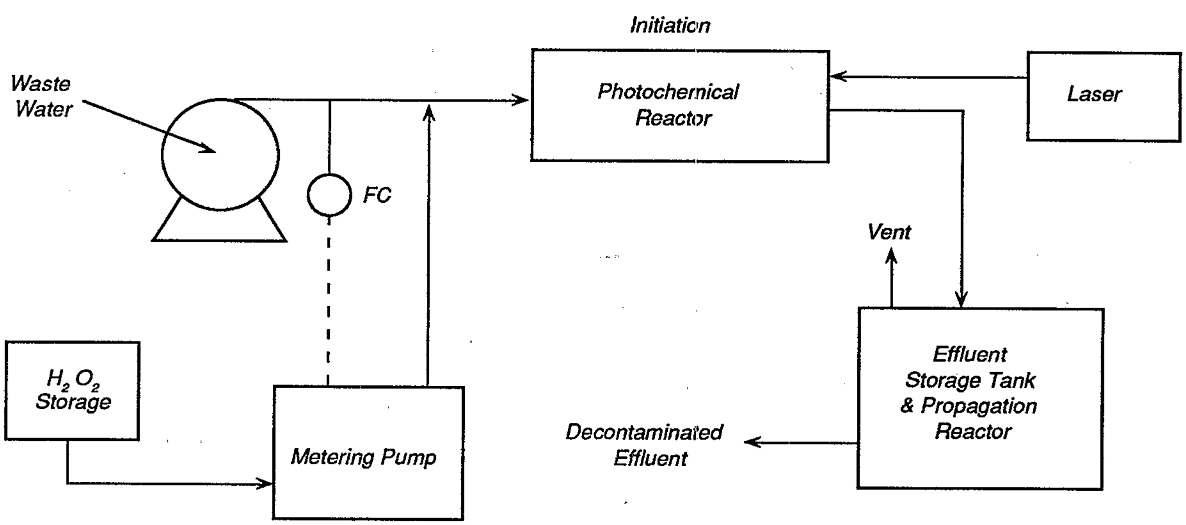

Figure 1. *Process Flow Scheme.*

as $CaCO_3$) may be added to the storage tank to neutralize any halogenated acids formed when treating fluids contaminated with halogenated hydrocarbons.

The reaction kinetics depend on:

a) toxicant concentration
b) peroxide concentration
c) irradiation dose
d) irradiation frequency

Waste Applicability: This technology can be applied to groundwater and industrial wastewater containing organics.

Test Results: Table 1 presents typical reaction times for given levels of destruction for several toxicants of concern.

Table 1. *Destruction of Toxic Organics by Laser-Induced Photochemical Oxidation*

Compound	*Reaction Time (hr)*	*Destruction Achieved*
Benzene	*96*	*0.91*
Benzidine	*288*	*0.88*
Chlorobenzene	*114*	*0.98*
Chlorophenol	*72*	*0.99*
Dichloroethene	*624*	*0.88*
Phenol	*72*	*0.99*

$$\text{Destruction Achieved}_{net} = \frac{C_{in}^{*} - C_{out}^{*}}{C_{in}} - \frac{C_{in} - C_{out}}{C_{in}}$$

Where
C_{in}^{*} = Contaminant Concentration in to reactor, with irradiation
C_{out}^{*} = Contaminant Concentration out of reactor, with irradiation
C_{in} = Contaminant Concentration in to reactor, no irradiation
C_{out} = Contaminant Concentration out of reactor, no irradiation

Table 2 lists the compounds that can be treated successfully by Laser-Induced Photochemical Oxidative Destruction.

Table 2. *Compounds Treated with UV/Oxidation*

Ethers	*Pesticides*	*Aromatic Amines*
BTEX	*Citric Acid*	*Complexed Cyanides*
Phenol	*TCA*	*Polynuclear Aromatics*
TCE	*DCA*	*Dioxins*
PCE	*Me Cl_2*	*Hydrazine*
DCE	*Cresols*	*RDX*
Polynitrophenols	*PCBs*	*1,4 Dioxane*
Ketones	*PCP*	*EDTA*
Vinyl Chloride	*TNT*	*Hydrazine*

The process is now entering the initial phases of commercialization, with the company offering to conduct treatability studies for prospective clients. Preliminary cost evaluation shows that the process is very competitive compared to other UV oxidation processes and carbon adsorption.

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