Tech Data Sheet

Naval Facilities Engineering Command
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Management of Secondary Treatment Trains

INTRODUCTION

Secondary treatment is the destruction or removal of contaminants from remedial waste streams prior to discharge of treatment effluent. The objectives for managing a secondary treatment train are to identify the best remediation technology for the contaminants of concern, and then to determine what treatment technology is applicable at the site. Four technologies are most commonly used for secondary treatment processes: air stripping, granular activated carbon (GAC), advanced oxidation processes (AOPs), and biological treatment.

AIR STRIPPING

Air stripping is the mass transfer of compounds from an aqueous stream to a gaseous stream. Air stripping is used to separate halogenated and nonhalogenated volatile organic compounds (VOCs) from water, but it is not effective for contaminants with low vapor pressure or high solubility. Two types of air stripping systems are commonly used for the removal of contaminants: the packed tower design, which is used in high flow cases; and low-profile aeration systems, which are used in low flow cases. Packed tower air strippers are installed either as permanent installations on concrete pads or on a trailer. Low-profile air strippers are small package units suitable for skid or floor mounting.

Packed Tower (air stripping)

GRANULAR ACTIVATED CARBON

Liquid-phase granular activated carbon (GAC) treatment is performed by pumping groundwater through a vessel containing activated carbon. An intermolecuar attraction occurs between molecules of a dissolved chemical (adsorbate) and the GAC (adsorbent) surface, which results in adsorbtive forces that physically attract the adsorbate to the GAC as water passes through the vessel. The two common reactor configurations for GAC systems are the pulsed, or moving bed, and the fixed bed. The fixed bed design is the most commonly used for adsorption from liquids.

ADVANCED OXIDATION PROCESSES

Advanced oxidation processes (AOPs) involve the transfer of one or more electrons from an electron donor (reductant) to an electron acceptor (oxidant), which has a higher affinity for electrons. The end products of complete oxidation of organic compounds are CO_2 and H_2O. Chemical oxidation involves mixing groundwater with the oxidation agent in a vessel that allows sufficient residence time for oxidation. Some oxidants that are widely used for the treatment of organic contaminants are fluorine, ozone, chlorine, hydrogen peroxide, hypochlorites, and chlorine dioxide. hydrogen peroxide/ozone (H_2O_2/O_3), ozone/UV (O_3/UV), and hydrogen peroxide/UV (H_2O_2/UV) are all examples of advanced oxidation processes.

BIOLOGICAL TREATMENT

Biological treatment is the conversion of organic matter to gaseous end products and cell tissue via aerobic, anaerobic, or facultative suspended or attached growth systems. Bioreactors are ex situ systems designed to degrade the contaminants in pumped wastewater using microorganisms. In suspended growth systems, such as fluidized beds or sequencing batch reactors, contaminated wastewater is circulated in an aeration basin where a microbial population aerobically degrades organic matter. In the attached growth systems, such as trickling filters, upflow fixed film bioreactors, and rotating biological contactors, microorganisms are grown as a biofilm on a solid growth support matrix and contaminants are degraded as they diffuse into the biofilm.

Rotating Biological Contactor (RBC)

SUMMARY

The design and management of a secondary treatment train requires extensive planning on the part of the Remedial Project Manager (RPM). Each treatment technology has its own advantages and limitations, which may vary from site to site. Capital, installation and setup, startup, and operation and maintenance (O&M) costs associated with each technology also must be considered when choosing a secondary treatment. All of these factors should be assessed by RPMs to determine the best treatment regimen for their sites.

Cost Information

Air Stripping	GAC	AOPs	Biological Treatment
Packed Tower Capital $2.0M Annual O&M $75K **Low-Profile** Capital $108K Annual O&M $18.5K	Annual O&M $61K-$6,500K Unit Cost (per 1,000 gal) $0.50-$5.00	**H_2O_2/UV** Capital $177K-$10,000K Annual O&M $54K-$4,000K **H_2O_2/O_3** Capital $144K-$10,000K Annual O&M $50K-$1,500K	**Mature Bioreactor** Unit Cost (per 1,000 gal) $0.50-$3.00 **Emerging Bioreactor** Unit Cost (per 1,000 gal) $5.00-$20.00

The table below summarizes the target compounds, advantages, and disadvantages for each of the four treatment technologies discussed. The first step in choosing a secondary treatment technology is to determine which technology will successfully remediate the contaminant of concern. Second, cost considerations and advantages/disadvantages are examined before making a final technology selection.

Treatment Type	Target Compound(s)	Advantages	Disadvantages
Air Stripping	•Halogenated and nonhalogenated VOCs (i.e., BTEX, TCE, DCE, PCE, and chloroethane)	•Ease of operation •Computer models available for design •Low capital and operating costs	•Corrosion •Scaling •Iron fouling •Biological fouling •Off-gas treatment •Aesthetics (tower)
Granular Activated Carbon	•Halogenated and nonhalogenated VOCs •SVOCs •PCBs •Explosives	•Reliability •Flexibility •Ease of implementation •No off-gas treatment •Low capital installation costs	•Impact of other soluble organic compounds (SOCs) •Desorption •Operating costs •Fouling •Disposal of spent carbon
Advanced Oxidation Processes H_2O_2/O_3, O_3/UV, H_2O_2/UV	•Halogenated and nonhalogenated VOCs •SVOCs •PCBs •Ordnance compounds	•Rapid destructive process •Disinfection capability •Established technology •Regulatory acceptance •Hydroxyl radical formation	•Water quality •Oxidation byproducts •Bromate formation •Interfering compounds •Air permit for ozone emissions •Mercury contamination from mercury sleeves
Biological Treatment	•Nonhalogenated VOCs •SVOCs •Gasoline and diesel fuel •JP-4 and JP-5 •Heavy fuel oil (PCBs, halogenated VOCs, and halogenated SVOCs require a cometabolic growth substrate)	•Bioreactors with adapted microorganisms •Treatment of large volumes of water	•Residual biomass may require additional treatment •High contaminant concentrations may be toxic •Temperature affects biodegradation rates

To facilitate evaluation of secondary treatment options, NAVFAC has prepared a web site called the Ex Situ Groundwater Treatment Technologies Evaluation Tool. This web tool includes 18 treatment technologies and has two primary functions: technology evaluation and treatment train evaluation. The technology evaluation portion of the tool allows the user to view technologies according to their developmental status (i.e., conventional, innovative, or emerging) and provides cost ranges, technology descriptions, schematic diagrams, tables listing technology advantages and limitations, as well as vendor information. The treatment train evaluation component allows site-specific identification of treatment trains based on contaminants of concern (COCs), flowrate, inlet COC concentration, removal efficiency, and various water quality parameters.
http://enviro.nfesc.navy.mil/erb/erb_a/restoration/technologies/sel_tools/secondary/default.asp

FOR FURTHER INFORMATION (805) 982-6586