Bioreactors: Role in Organic compound and VOCs degradation

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Bioreactor treatment may be performed using microorganisms growing in suspense ion in the fluid or attached on a solid growth support medium. In suspended growth systems, such as fluidized beds or sequencing batch reactors, contaminated groundwater is circulated in an aeration basin where a microbial population aerobically degrades organic matter and produces carbon dioxide, water, and biomass. The biomass is settled out in a clarifier, then either recycled back to the aeration basin or disposed of as sludge. In attached growth systems, such as upflow fixed film bioreactors, rotating biological contractors (RBCs), and trickling filters, microorganisms are grown as a biofilm on a solid growth support matrix and water contaminants are degraded as they diffuse into the biofilm. Support media include solids that have a large surface area for bacterial attachment. Commonly, the support matrix is an adsorptive medium, such as activated carbon, that can adsorb contaminants and slowly release them to the microorganisms for degradation. Other support media include plastic or ceramic packing and even sands and gravels have been used. The microbial population may be derived from natural selection in the reactor, from an enrichment from the contaminated media, or from an inoculum of organisms with specific contaminant- degrading capabilities.

Conventional (bioreactors); emerging (bioreactors with cometabolites, bioreactors with adapted microorganisms, and sequential anaerobic/aerobic bioreactors). Bioreactors are used primarily to treat nonhalogenated volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), including gasoline, diesel fuel, JP-4, JP-5, and heavy fuel oil in extracted groundwater. For more specialized applications such as treatment of polychlorinated biphenyls (PCBs), halogenated VOCs, and halogenated SVOCs in extracted groundwater, addition of cometabolites may be required to provide the microorganisms with a growth substrate and/or enzyme inducer. Bioreactors employing specially adapted microorganisms can be used to treat halogenated SVOCs, pesticides, PCBs, and ordnance compounds. Sequencing anaerobic/aerobic bioreactors is an innovative approach for treating halogenated VOCs, SVOCs, pesticides, PCBs, and ordnance compounds.

The following factors may limit the applicability and effectiveness of the process:

- Residual biomass (sludge) may require additional treatment and/or specialized disposal.
- Very high contaminant concentrations may be toxic to microorganisms.
- Air pollution controls may be needed to reduce emission of volatile compounds from aerated and/or well-mixed bioreactor systems.
- Low ambient temperatures can decrease biodegradation rates.
- Bioreactors can be prone to upset and nuisance microorganisms can predominate and reduce treatment effectiveness.
- Fixed film bioreactors may not be applicable for contaminants with low diffusivities due to mass transfer limitations.
- Heavy metals are not treated by this method and can be toxic to microorganisms

Bioreactors are used to treat pumped groundwater or wastewater residual from a treatment process. The operation and maintenance duration depends on the duration of the primary process operation capital, installation and setup, startup, and operation and maintenance costs associated with bioreactors can be significant and the economy of scale must be taken into account when considering using these technologies for treating contaminated groundwater. Bioreactors are more appropriate for treating larger volumes of water when contaminant destruction, not simply transfer to another medium, is required. Costs for bioreactor treatment should be competitive with alternative physical/chemical treatment technologies and should fall in the range of $0.50 to $3.00 per 1,000 gallons for mature bioreactor technology applications and $5.00 to $20.00 per 1,000 gallons for emerging bioreactor technology applications.