Degradation of Acetaldehyde in Biotrickling Filters

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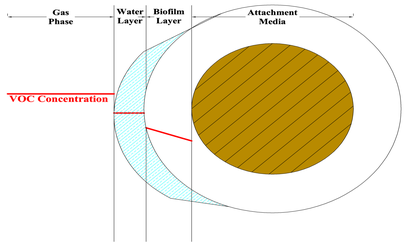
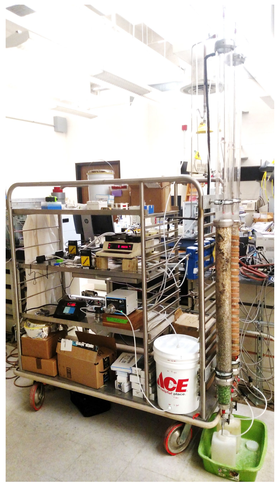
WHAT IS A BIOTRICKLING FILTER?

Biotrickling filters (BTFs) are an air treatment technology. They use the metabolic action of microorganisms to clean air of volatile organic compounds.

BTFs are packed beds. Despite the name, BTFs do not 'filter' air in an actual sense. Microorganisms are allowed to grow on the packing material, forming a biofilm. Pollutants diffuse into the biofilm and are subsequently biodegraded.





BACKGROUND

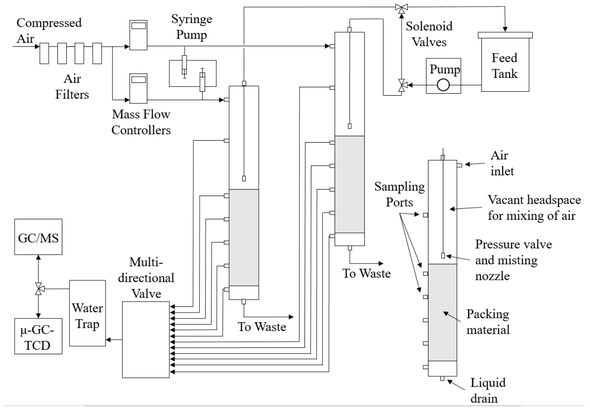
- Emissions from ethanol production facilities include hazardous air pollutants (HAPs) in concentrations up to 30 ppm.
- Acetaldehyde, formaldehyde and ethanol are the most common pollutants, present in the emissions from fermentation tanks and distillers dried grains with solubles driers.
- Current technologies used for the control of HAP emissions are regenerative thermal oxidizer (RTO) and chemical scrubbing.
- RTO is utility intensive and environmentally unfavorable while scrubbing requires high water and energy inputs. Large volume of scrubber blowdown must be discharged, or recycled.
- Biological treatment is presented as a favorable alternative.
- Two biofilters were operated in series in co-current downward flow.

EXPERIMENTAL APPARATUS

Two biofilters are operated in parallel. One is operated at room temperature and the other is heated to 50°C. The room temperature column simulates emissions from fermentation tanks while the heated column predicts BTF performance from DDGS dryers.

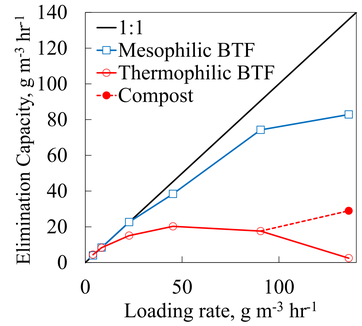
A syringe pump injects acetaldehyde into a stream of filtered air and is fed to each column at a rate of 8 L/min for an empty bed resident time (EBRT) of 31 seconds. A buffered nutrient solution is also fed to each column intermittently at an average rate of approximately 1 L/day. BTF operation is fully automated.

Each column is equipped with six sampling ports. Flow from any of these ports may be directed to either a μ-GC-TCD or a GC/MS for quantitative analysis.

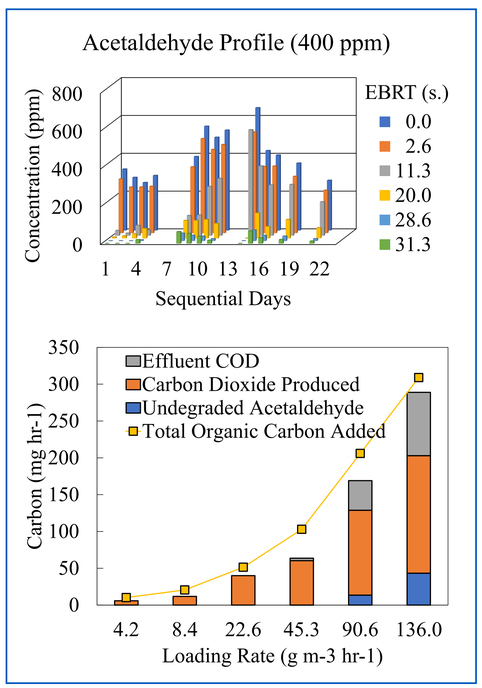


RESULTS

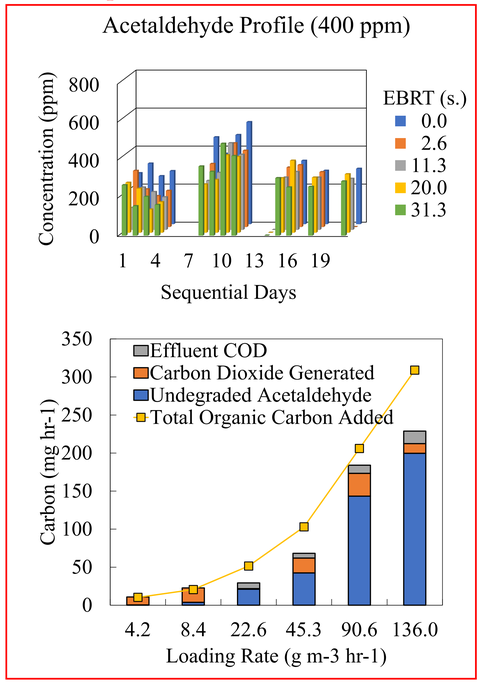
Phase	Duration	Air Flow Rate	Inlet Conc.	Loading Rate	Removal Efficiency	
	Days	L/min.	ppm	g/m³/hr.	Cold	Hot
1	18	8.00	20	4.2	100	100
2	19	8.00	40	8.4	100	100
3	20	8.00	100	22.6	100	67
4	23	8.00	200	45.3	100	61
5	21	8.00	400	90.6	93	24
6	23	8.00	600	136.0	91	9



Mesophilic BTF



Thermophilic BTF



CONCLUSION

- The room temperature BTF showed excellent removal efficiency for loading rates below 90 g $m^{-3}hr^{-1}$. A maximum elimination capacity of 90 g $m^{-3}hr^{-1}$ is expected due to visible trend.
- For thermophilic BTF, a maximum elimination capacity of 20 g $m^{-3}hr^{-1}$ was achieved.
- At loading rates above 44 g $m^{-3}hr^{-1}$ performance of thermophilic BTF deteriorated.
- This deterioration due to lower Henry's law constant, extreme temperature fluctuations, and accumulation of salts
- Reseeding of thermophilic BTF with a slurry prepared from cooking compost revitalized the bed performance.
- Carbon balance performed over mesophilic BTF shows CO2 generation and biomass accumulation proportional to elimination capacity through phase IV. Decrease in biomass accumulation in phases V and VI due to overgrowth and flushing of biomass
- Lower comparable effluent VSS and COD observed in thermophilic BTF, especially at high loading rates
- Acetate identified as major soluble degradation byproduct.

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