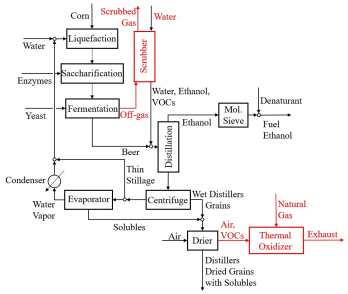
Treatment of Hazardous Air Pollutants (HAP)s in Ethanol Plant Exhaust by Using a Bio-Trickling Filter

Katie Mowat (Donesky), EIT

Introduction/Background

The US consumed 14.4 billion gallons of ethanol in 2018. There are 24 ethanol plants in the state of Nebraska. These plants produce this alternative biofuel through the fermentation of organic matter such as corn. Ethanol plants also produce hazardous air pollutants (HAPs) during the fermentation of organic matter. Both Regenerative Thermal Oxidizers (RTOs) and CO_2 scrubbers are currently used to treat the exhaust before it is released into the atmosphere. These traditional treatment methods require lots of water and natural gas to operate.



Objective/Purpose

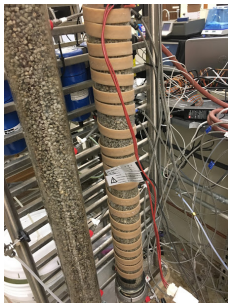
The goal of this research study is to look into the use of a bio-trickling filter (BTF) as an alternate ethanol plant exhaust scrubbing device. A BTF's water consumption is less than 0.5% of that of a CO_2 scrubber and it uses no natural gas.

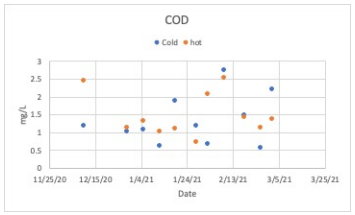
To meet this goal, a lab scale BTF was built and common HAPs: Acetaldehyde, Formaldehyde, Ethanol, and Methanol, were run through it. Once it was proven that the columns could treat each compound individually, mixtures were created to see if the column could treat a synthetic exhaust flow.

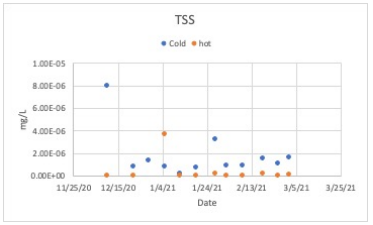
Experimental Apparatus

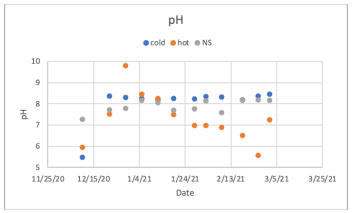
The lab scale BTF is made up of two different columns in parallel. A mesophilic BTF (25°C) and thermophilic BTF (60°C). The mesophilic BTF simulates emissions from the fermenters and the thermophilic BTF simulates emissions from the DDGS dryers.

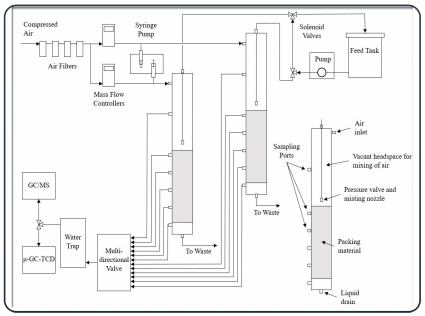
Filtered air at a rate of 8 L/min volatilizes the solutions listed in the mixture table that are injected into the air line using a syringe pump. Sampling ports along the BTF columns are directed to a multidirectional valve and then to either the Gas chromatography with mass spectrometry (GC/MS), microGC, or Fourier Transform Infrared (FTIR) analyzer to be analyzed. The feed tank contains a nutrient solution that is pumped to the BTFs at a rate of 2 L/day.











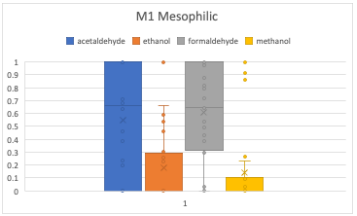
Data/Results

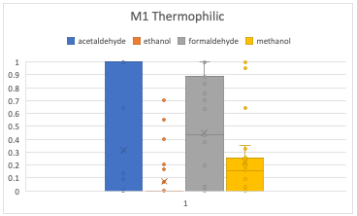
Mixtures at concentrations shown in Table 1 are and will be run through the columns. So far mixtures 1 and 2 have been run though the columns and results can be seen in the graphs to the right.

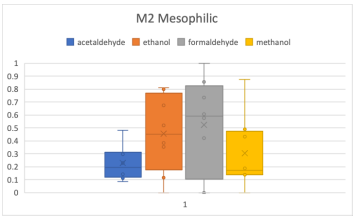
Carbon oxygen demand (COD), pH, and TSS measurements were taken once a week from each column.

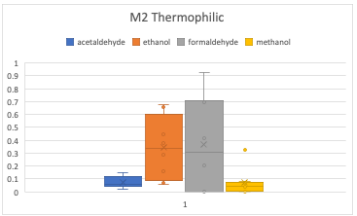
Mixtures

Compounds	Mixture 1 (ppm)	Mixture 2 (ppm)	Mixture 3 (ppm)	Mixture 4 (ppm)	Mixture 5 (ppm)
Ethanol	50	100	500	1000	1500
Acetaldehyde	100	100	100	100	100
Formaldehyde	50	50	50	50	50
Methanol	13.5	13.5	13.5	13.5	13.5









Conclusions

It takes about 2 weeks to equalize a mixture in the columns.

pH increases coming out of the cold column and decreases out of the hot column.

COD readings are between 0.5-3 mg/L for both columns.

Amount of nutrient solution flowing through the columns effects the readings.

Mixtures have an affect on the readings.

Ions overlap on the GCMS readings causing uncertainty in analysis and calibration.

Mixtures also effect FTIR methanol wavelengths.

Future Work

Run mixtures 3, 4, and 5 through the columns to get a full picture of how the BTF is affected by the synthetic exhaust.

Create more robust calibration curves.

Acknowledgments/Thank-you

My advisors: Dr. Bruce Dvorak and Dr. Ashraf Aly Hassan

Lab Help: Cameron Raszler, Nathan Kreutzer, Gabriel Cohen, Purity Muhia, and Andrew Donesky

Funding: Nebraska Public Power District and the Nebraska Center for Energy Science Research

University of Nebraska Lincoln | Nebraska Center for Energy Sciences Research