Warren J. Baker Endowment
for Excellence in Project-Based Learning
Robert D. Koob Endowment *for Student Success*

FINAL REPORT

Final reports will be published on the Cal Poly Digital Commons website(http://digitalcommons.calpoly.edu).

I. Project Title

Indoor air monitoring of select volatile organic compounds in wineries using active sampling and gas chromatography-mass spectrometry

II. Project Completion Date

Projected Thesis Defense: March 2018

III. Student(s), Department(s), and Major(s)

(1) Andrew Kaneda, Civil and Environmental Engineering Department, Civil and Environmental Engineering Student

IV. Faculty Advisor and Department

Dr. Tracy Thatcher, Civil and Environmental Engineering Department

V. Cooperating Industry, Agency, Non-Profit, or University Organization(s)

Cal Poly Wine and Viticulture Department

VI. Executive Summary

Volatile organic compounds (VOCs) are a group of chemicals that are correlated with increased formation of photochemical smog and increased health risks in humans. The goals of this thesis project were to determine the presence of select VOCs in the Cal Poly pilot winery, as well as estimate the ethanol emissions from the pilot winery during the Fall 2018 fermentation season. Estimated ethanol emissions were then compared to emission estimates from the United States Environmental Protection Agency (USEPA).

The selected VOCs that were sampled for include: ethanol, benzene, toluene, ethylbenzene, xylene, styrene, and limonene. Winery air during fermentation was collected via active sampling using sorbent tubes as the collection medium. Ethanol and benzene were determined to be present in the pilot winery air, while there was no significant evidence for the presence of toluene, ethylbenzene, xylene, styrene, nor limonene. Maximum average benzene concentrations were measured to be 150 $\mu g/m^3$ in the pilot winery, below the Occupational Health and Safety Administration (OSHA) and California OSHA (CAL/OSHA) 8-hour time-weighted average regulatory limits of 31.9 and 3.19 mg/m^3 respectively. Ethanol concentrations inside of the pilot winery were measured to reach a maximum average concentration of 16.1 mg/m^3, complying with the OSHA and CAL/OSHA 8-hour time weighted average regulatory limit of 1900 mg/m^3.

To estimate the ethanol emissions from the pilot winery, the air exchange rate (AER) of the pilot winery was determined using a CO_2 tracer-gas study and calculated to be 22 ± 18 hr^{-1}. Using the determined AER and the indoor concentration of ethanol at different stages of fermentation, an emission rate of 207 ± 169 pounds of ethanol per 1000 gallons of wine produced was calculated. Compared to field emission data collected by the USEPA, estimated ethanol emissions from this project are greater by 370% to 3770%, depending on the AER used to calculate the emissions.

Future work concerning the estimation of ethanol emissions during fermentation should consider a sampling strategy that can accurately measure ethanol release at the source, rather than estimating source generation from a room average.

VII. Major Accomplishments

(1) Successfully created experiments to determine the air exchange rate and select VOC concentrations within the Cal Poly pilot winery.

(2) Successfully quantified ethanol and benzene concentrations within the Cal Poly Pilot winery during the crush and fermentation season using active sampling and Anasorb GCB1-packed sorbent tubes, comparing results to OSHA and CAL/OSHA regulatory limits.

(3) Successfully estimated ethanol emissions during fermentation and compared the emission rates to established EPA literature.

VIII. Expenditure of Funds

Quantity	Description	Price
20	Sorbent Tubes, Stainless Steel Thermal Desorption Tubes, Anasorb GCB1/Carbosieve S-III, Unpurged	$ 1,353.32
1	Methanol Solution Ethylbenzene, 5000 ug/mL, 1 mL standard Styrene, 2000 ug/mL, 1 mL standard Limonene, 2000 ug/mL, 1 mL standard Benzene, 200 ug/mL, 1 mL standard Toluene, 200 ug/mL, 1 mL standard o-Xylene, 5000 ug/mL, 1 mL standard m-Xylene, 5000 ug/mL, 1 mL standard p-Xylene, 5000 ug/mL, 1 mL standard S&H	$ 383.37
1	Ethanol, 2000 ug/mL, 1 mL standard S&H	$ 46.32
1	11 mm Amber Glass Snap-It Target LoVials with ID, 2 mL, 100 pk 11 mm Autosampler Snap-It Blue Caps, 6 mm opening, clear PTFE/synthetic red rubber septa S&H	$ 106.24
3	20 lb CO2 gas cannisters	$ 89.90

Total	$ 1,979.15

IX. Impact on Student Learning

The money received from the Baker-Koob endowment provided complete funding for all my analytical supplies: sorbent tubes, calibration standards, sample vials, and CO_2 cannisters. These supplies were essential to evaluating indoor air concentrations of the select VOCs. Without the generous support of this endowment, my thesis project would not have been possible.

This thesis project has been an amazing opportunity for me to learn more about the field of indoor air quality and wine production. The project also allowed me to expand on my skills learned from the Cal Poly environmental engineering undergraduate program: I had to design my own experiments to determine the pilot winery's air exchange rate and calibrate the gas chromatographer-mass spectrometer, overcome problems in the field during sampling to ensure that the data being collected was representative of the conditions, and analyze my data with previous research from the United States Environmental Protection Agency.

I am also grateful for the opportunity to collaborate with the Wine & Viticulture graduate students and staff during my thesis project. They were all extremely helpful with teaching me about their projects and offering insight into their methods of wine-making. I had no prior experience with

viticulture, so this was an opportunity for me to understand how wine is created on a small scale. I also gained insight as to how wineries can scale up in production using similar techniques that were being applied at the Cal Poly pilot winery. I plan to continue expanding my learning in both the field of air quality and wine making throughout my professional career.