M.S. Defense Announcement
Derek Weber
December 15, 2017 at 2:00pm

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Friday, December 15, 2017
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Defense
ATS Large Classroom (101 ATS)

Post Defense Meeting
Riehl Room (211 ACRC)

Committee:
Jeffrey Collett (Advisor)
Arsineh Hecobian
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Shantanu Jathar (Mechanical Engineering)

Volatile Organic Compound Concentrations and the Impacts of Future Oil and Natural Gas Development in the Colorado Northern Front Range

Recent advances in unconventional extraction of oil and natural gas (O&NG) have caused an increase in the number of wells in the Colorado Northern Front Range (CNFR) which has doubled Colorado's natural gas production over the last 15 years. Increased O&NG activity can lead to increased emissions of Volatile Organic Compounds (VOCs) which may negatively impact air quality and human health. This study looks at five sites (an elementary school, residential area, Fossil Creek Natural Area, Soapstone Natural Area and a gas station) in Fort Collins and Timnath with the objectives of determining the gradient of VOC concentrations across a subsection of the CNFR, providing a baseline to compare potentially elevated VOC concentrations from future O&NG development, and a better understanding of the influence of O&NG emissions on air quality in the CNFR. Whole air samples were collected at all locations using an evacuated 6L stainless steel canister equipped with a calibrated flow controller that sampled at a constant flow rate for approximately 1 week. Sampling began at the elementary school and gas station in the summer of 2015 and concluded in November of 2016. Sampling at the two natural areas and the residential area took place in the fall of 2015. VOC concentrations were analyzed using an online gas chromatography flame ionization detector (GC-FID) system. An in-situ real-time GC was also deployed along with an All-In-One (AIO) weather station at the residential area providing hourly VOC and meteorological measurements for approximately 3 weeks in the fall of 2015.

A suite of 48 VOCs were measured in this study. Ambient concentrations of BTEX compounds (Benzene, Toluene, Ethylbenzene and Xylenes) are often of particular interest due to their carcinogenic effects and toxicity; therefore, they were studied in-depth as part of this thesis. Benzene was found to have median ambient concentration at the elementary school, residential area, Fossil Creek Natural Area, Soapstone Natural Area, and the gas station of 0.18, 0.14, 0.32, 0.09, and 0.55ppbv, respectively.

Through the use of VOC correlations with propane and acetylene and VOC ratios, it was determined that O&NG emissions have a large influence on ambient VOC concentrations in the CNFR. The mean ratio of i-pentane to n-pentane found at the elementary school, residential area, Fossil Creek Natural Area, Soapstone Natural Area, and the gas station was 1.07, 1.17, 1.16, 1.05, and 2.35, respectively. This indicates that the elementary school and Soapstone Natural Area are strongly influence by O&NG emissions while the residential area and Fossil Creek Natural Area have a mixed influence from O&NG activity as well as vehicular emissions. In contrast the gas station, displayed a clear combustion signature, as expected. In addition, through the use of meteorological data coupled with the real-time GC VOC measurements, there is strong evidence that local O&NG sources can have a large impact on air quality at the residential area.

The OH reactivity at each location was evaluated in order to compare the ozone production potential by the VOCs measured at each site. Fossil Creek NA showed the largest total OH reactivity in the fall while Soapstone NA displayed the lowest. At Soapstone NA, 66.7% of the total OH reactivity resulted from aromatics, which is the highest, and 11.4% resulted from alkenes, which is the lowest compared to each group's contribution at other sites. At the elementary school, 3.2% of the OH reactivity in the summer was attributed to isoprene, whereas in the fall, winter, and spring only 2.0%, 0.41%, and 0.76% of the OH reactivity resulted from isoprene, respectively.

Development of new unconventional O&NG wells is ongoing in the CNFR and there are plans to develop wells in close proximity to the elementary school. The American Meteorological Society (AMS)/Environmental Protection Agency (EPA) steady-state dispersion model AERMOD was utilized to project the potential increased concentration of benzene as a resulted of this development. The model was run utilizing the 5th, 25th, median, 75th, and 95th percentile emission rates of benzene found by a past study at production sites in the CNFR. The annual average concentration increases above background at the school (0.18 ± 0.08ppbv) for the 5th, 25th, median, 75th, and 95th percentile emission rates were found to be 0.0067, 0.11, 0.33, 0.89, and 6.7ppbv, respectively. The strongest benzene enhancement at the school occurred 0:00 (midnight) - 08:00 and 17:00 - 23:00 (0.46ppbv); however, during school attendance hours (08:35 - 15:13) the concentration increase was 0.024ppbv.