M.S. Defense Announcement
Weixin Zhang
Thursday, May 30, at 10:00 am

Weixin Zhang
M.S. Defense

May 30, 2024
10:00 am

Defense
ATS Large Classroom (101 ATS) or Teams

Post Defense Meeting
Riehl Conference Room (211 ACRC)

Committee:
Jeffrey Collett (Advisor)
Da Pan
Jeffrey Pierce
Jay Ham (Soil and Crop Sciences)

QUANTIFICATION OF VOLATILE ORGANIC COMPOUND EMISSIONS FROM UNCONVENTIONAL OIL AND GAS DEVELOPMENT

Oil and gas (O&G) development in the U.S. has accelerated in the past two decades, aided by unconventional extraction techniques including hydraulic fracturing and horizontal drilling. Potential environmental and health impacts of volatile organic compounds (VOCs) originating from O&G activities in populated regions have raised concerns. In Broomfield, Colorado, six new O&G well pads were approved for development in 2017 and an air monitoring program was established in October 2018 to collect weekly and later plume-triggered air samples. This study addresses the limited existing knowledge of activity-specific VOC emission rates from unconventional O&G development (UOGD), utilizing these observations and dispersion model simulations through emission inversion methods. Emissions are characterized from well drilling, hydraulic fracturing, coiled tubing/millout, flowback, and production operations.

Substantial variations in average VOC emission rates, determined using weekly canister observations, are observed across different UOGD phases. Drilling and coiled tubing/millout operations exhibit the highest total VOC emission rates, attributed to hydrocarbon release from shale formations and drilling mud. In contrast, hydraulic fracturing gives lower emission rates, consistent with injection of fluids into the well during this operation, minimizing the probability of subsurface hydrocarbon emissions. Diesel-powered engines are identified as the primary ethyne sources during hydraulic fracturing. Production was characterized by lower VOC emission rates than pre-production phases but remains an important emission category due to its long duration (decades). Variations of emission rates within each phase highlight the complexity of factors and activities influencing emission rates, including, for example, vertical vs. horizontal drilling and periodic maintenance activities. VOC emission rates associated with drilling mud volatilization and hydraulic fracturing suggest that previously published emission estimates (EPA (2022), and Hecobian et al. (2019)) underestimate average VOC emission rates during these activities. Significantly lower emission rates during flowback compared to previous work (Hecobian et al., 2019) reveal how improved management practices, including tankless, closed-loop fluid handling systems have effectively reduced what used to be a dominant source of pre-production VOC emissions. Plume-triggered samples, capturing transient high-concentration plumes, reveal short-term VOC emission rates approximately an order of magnitude higher for drilling and flowback than determined from weekly samples. In the case of flowback, short-term emission pulses have been linked to periodic emptying of sand canisters used to trap fracking sand emerging from previously fracked wells.