Livestock production is a growing source of air pollution at regional, national, and global scales. Improved livestock manure management has the potential to reduce environmental impacts; however, there is an urgent need for cost-efficient, reliable, and easy to maintain measurement and monitoring capabilities to precisely quantify emissions from livestock manure. This research describes and evaluates a novel measurement method based on the multiplexed portable Fourier Transform Infrared (FTIR) spectroscopy analyzer - surface chamber techniques for continuous measurements and monitoring gas emissions from manure sources. The multiplexing system was designed and developed to automate the chamber network, controlling the movement of chambers and accurately managing chamber air flow distribution. The measurement accuracy of the developed system was evaluated under controlled laboratory conditions. The result of the statistical hypothesis testing showed that there is no statistically significant differences among the measurement results from each of the twelve chambers.

While microbial activity is a key factor for formation of gaseous compounds in manure, the magnitude of gas exchange between manure and the atmosphere largely depends on manure physical characteristics. A series of soil science measurement and modeling techniques were applied to determine a set of fundamental physical, hydraulics, and thermal properties of cattle manure to support advanced modeling of gas emissions from manure sources. The liquid water retention characteristic for cattle manure was found to be close to that of organic peat soils. The results also suggested that Richards equation can describe the hydrodynamics taking place in cattle manure relevant to natural drying processes. However, the uncertainties of the measurement results could be due to the complexity of shrinkage, surface crust formation, and shrinkage cracks.

Carbon dioxide (CO2) and methane (CH4) emissions were estimated and characterized in field plots using the developed gas emission measurement system. The measurements included four treatments; beef manure, dairy manure, beef compost, and dairy compost. The estimated CO2 and CH4 emissions from the surface application with dairy manure were the highest among other treatments, while the CO2 and CH4 emissions from the surface application with beef compost were the lowest. Impacts of temperature and water content on CO2 and CH4 emissions were found to be correlated significantly.
Overall, this dissertation provides a solid foundation upon which future research can build in better understanding and modeling animal waste emission processes that impact the environment.