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Emissions of Odor, Ammonia, Hydrogen Sulfide, and Volatile Organic Compounds from Shallow-Pit Pig Nursery Rooms

Gopi Krishna Kafle*, Lide Chen*

Department of Biological and Agricultural Engineering, University of Idaho, Moscow, ID 83844, USA

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Abstract

Purpose: The objective of this study was to measure emissions of gases (ammonia (NH_3), hydrogen sulfide (H_2S) and carbon dioxide (CO_2)), volatile organic compounds (VOC) and odor from two shallow pit pig nursery rooms. Gas and odor reduction practices for swine operations based on the literature were also discussed. **Methods:** This study was conducted for 60 days at a commercial swine nursery facility which consisted of four identical rooms with mechanical ventilations. Two rooms (room 1 (R1) and room 2 (R2)) with different pig numbers and ventilation rates were used in this study. The pig manure from both the R1 and R2 were characterized. Indoor/outdoor temperatures, ventilation rates/duration, NH_3, H_2S, CO_2, and VOC concentrations of the ventilation air were measured periodically (3-5 times/week). Odor concentrations of the ventilations were measured two times on two days. Three different types of gas and odor reduction practices (diet control, chemical method, and biological method) were discussed in this study. **Results:** The volatile solids to total solids ratio (VS/TS) and crude protein (CP) value of pig manure indicated the pig manure had high potential for gas and odor emissions. The NH_3, H_2S, CO_2 and VOC concentrations were measured in the ranges of 1.0-13.3, 0.1-5.7, 1600-3000 and 0.0-1.83 ppm, respectively. The NH_3 concentrations were found significantly higher than H2S concentrations for both rooms. The odor concentrations were measured in the range of 2853-4432 OU_E/m^3. There was significant difference in odor concentrations between the two rooms which was due to difference in pig numbers and ventilation duration. The literature studies showed that simultaneous use of dietary control and biofiltration practices will be more effective and environmentally friendly for gas and odor reductions from pig barns. **Conclusions:** The gas and odor concentrations measured in the ventilation air from the pig rooms indicate an acute need for using gas and odor mitigation technologies. Adopting diet control and biofiltration practices simultaneously could be the best option for mitigating gas and odor emissions from pig barns.

Keywords: Ammonia, Emission, Hydrogen sulfide, Pig, Odor, Volatile organic compounds (VOC)

Introduction

In recent decades, livestock production has shifted from small farms to industrialized operations with intensive confinement of animals and concentration of wastes. High-intensity livestock production satisfies the need to improve the efficiency of animal management. The concentration of livestock in stalls/barns or in open lots decreases labor requirements but increases the problem of waste disposal (Hays and Bianca, 1975). Concentrated animal feeding operations (CAFOs), including pig facilities, are sources of air pollutants, such as ammonia (NH_3), hydrogen sulfide (H_2S), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), volatile organic compounds (VOCs), particulate matter (PM), and odor that affect air quality. Sources of these emissions include barns, feedlot surfaces, composting structures, manure storage and treatment facilities, and land application areas. Emissions from animal agriculture are relevant to both local and global air pollution (Hood et al., 2011). Similarly, pig finishing operations near residential

***Corresponding author:** Gopi Krishna Kafle
Tel: +1-208-736-3604; **Fax:** +1-208-736-0843
E-mail: gopikafle@yahoo.com, gopik@uidaho.edu
Lide Chen
Tel: +1-208-736-3615; **Fax:** +1-208-736-0843
E-mail: lchen@uidaho.edu

areas can create public nuisance concerns due to the annoyance potential of odor emitted from the pig operations (Schauberger et al., 2013). Besides the nuisance associated with odors, they have also been shown to have a negative impact on the public health of people living in close proximity of the pig farms, where several studies have suggested odors from intensive pig farms to be the cause for several ailments (Schiffman et al. 1995; Merchant and Ross 2002). Schiffman et al. (1995) reported that persons living near pig operations who experienced the odors had significantly more tension, more depression, more anger, more fatigue and more confusion than control subjects as measured by the Profile of Mood States. As a follow-up to this study, Thu et al. (1997) published the results of another project based on physical and psychological health data from 18 neighbors living within a two-mile radius of a 4,000-pig operation in Iowa, USA. Neighbors of the swine operation reported experiencing significantly higher rates of four clusters of symptoms known to represent toxic or inflammatory effects on respiratory tracts.

As livestock production has become more concentrated and the make-up of rural communities has changed, neighbor complaints about odors from livestock operations have increased in number and visibility to the point where odor concerns are a primary barrier at the local level to grow livestock operations. Associated with this increase is the air pollution problem (odors) which has become the center of public concern. This is reflected in the increased frequency of odor-related complaints in areas where swine production facilities are more intensified. Odor management is currently impacting many aspects of the swine industry and there appears a potential that the sustainability, productivity, and profitability of swine producers will be dependent upon whether they can reduce the emission of offensive odorants from operating swine production units to a level which surrounding communities could tolerate. Therefore, there exists an acute need for effective methods of odor control, for if the swine industries are to coexist with their neighbors, such control measures will have to be put into operation (Zhu, 2000). Concern about the potential for animal waste pollution has emerged as one of the most critical environmental issues confronting pig producers in the U.S.

Exhaust ventilation air from livestock production buildings is a major source of pollution to the environment from agricultural operation. Indoor air quality in the building affects the well-being of both animals and workers. More detailed research identified the concentration levels of interior ambient airborne elements, including their interactive dynamics, which put exposed worker populations at risk. For example, recommended gas (7 ppm ammonia), dust (2.5 mg/m^3 total dust; 0.23 mg/m^3 respirable dust), and endotoxin (100 EU/m^3) levels have been developed for interior swine confinement operations based on dose–response research (Donham et al., 1995; Reynolds et al., 1996). Researchers have also noted that when these elements combine (e.g., ammonia attached to small dust particles), they may have an added negative health consequence. Many American agencies or organizations such as the United States Environmental Protection Agency, the Agency for Toxic Substances and Disease Registry have established threshold values for NH_3 and H_2S in ambient air. Based on these threshold values, on average, the NH_3 100 to 4,500 ppb; for the H_2S, 1.4 to 200 ppb, respectively (Lemay et al., 2007).

Since the state and federal governments may impose increasingly strict regulations on swine farms to reduce air and water pollution, the swine industry may have to respond by implementing new technologies and practices to reduce emissions.

Accurate estimation of air emissions from CAFOs is needed to predict their potential adverse impacts and to facilitate the selection of the most effective control measures. The US Environmental Protection Agency (EPA), the USDA Natural Resources Conservation Service (NRCS), as well as state and local governments, are seeking such information to assist them in making appropriate policy decisions to manage existing CAFOs, as well as plan for the construction, expansion or retrofits of CAFOs in their jurisdiction. In order to reduce NH_3, H_2S, VOC, and odor emissions from pig farms, it is firstly important to know the concentrations and emission rates associated with pig production systems. Thus, there is a need to know the amount of these pollutants being emitted from pig production buildings for simple regulatory purposes, but more importantly to determine how these airborne pollutants can be reduced to levels that will meet the regulatory limits, lower the impact of odors for neighbors, and minimize the risk to workers and pigs. The objectives for this research project were: (a) to measure the gas (NH_3, H_2S and CO_2) and VOC concentrations in the ventilated air; (b) to measure the odor concentration of the ventilated air; (c) to discuss the gas and odor mitigation practices.